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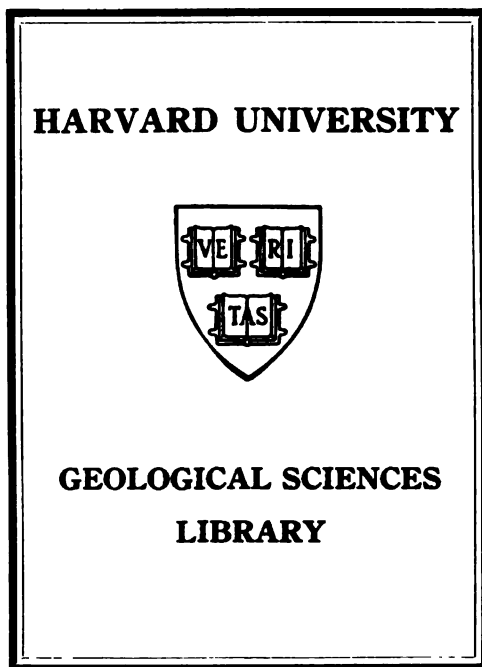
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THE  
TOPOGRAPHY AND GEOLOGY  
OF THE  
PENINSULA OF SINAI  
(WESTERN PORTION)

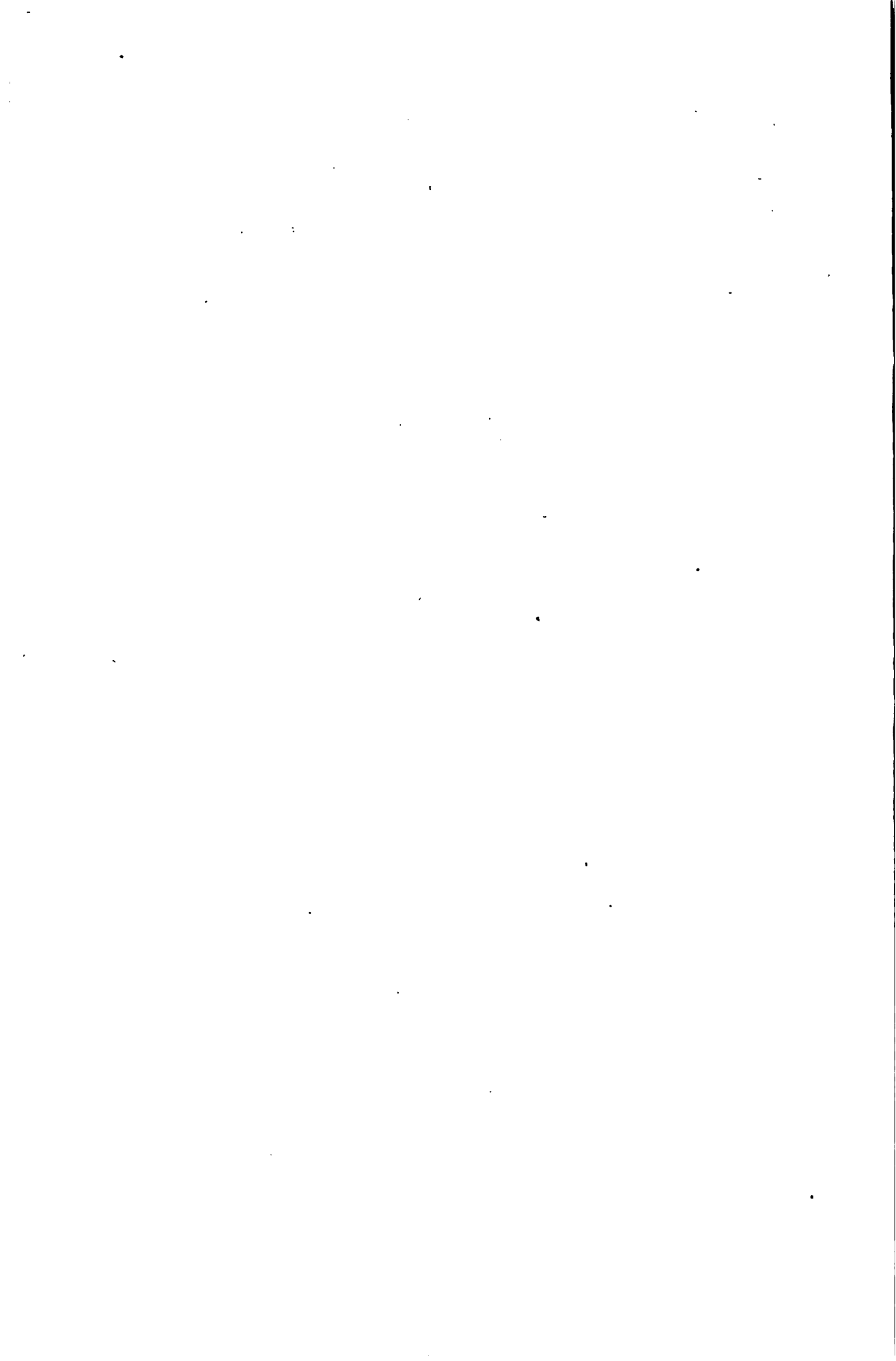
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**THE**  
**TOPOGRAPHY AND GEOLOGY**  
**OF**  
**WESTERN SINAI**

5  
1



	PAGE
(c).—LOWER EOCENE OR LIBYAN .. .. .	128

Foraminifera of Gebel Krer.—Junction of Wadis Baba and Shellal.—Absence of Eocene shales, etc.—Nature of Sinai peninsula in Eocene times.—Proofs of rapid subsidence.—Overlap.—Eocene fossils from above localities.

#### Section IV.—THE CRETACEOUS LIMESTONE AND SHALES. . . . . 131

Wide extension in Western Sinai.—Rev. F. W. Holland.—Bauerman's collections named by Duncan.—Cretaceous rocks mainly Cenomanian.—Possible presence of Turonian.—Fossils collected by Ordnance Survey.—Hull.—Walther.—Fourtau.—Gebel el Araba.—Thickness of strata.—Effect of faults.—Gebel Qabellat.—Gebel Safariat.—Dome broken by fault.—Gebel Asfar.—Steep dip of Cretaceous marls.—Wadi Thaghadi.—Gebel Abiad.—Gebel Khadahid.—Flinty limestone of Wadi Ferân.—*Gryphaea reticularis* limestone of Gebel el Rigma.—Origin of Qa plain.—Blanckenhorn's views.—Gebel Withr.—Wadi Budra.—Gebel Hadud.—Deposition of Miocene in Cretaceous basin.—Dolerite dyke cutting limestone.—Flinty limestone of Wadi Tayiba.—Hydrocarbons in limestone and basalt dyke.—Faulting of Cretaceous strata.—Gebel el Ti.—Thickness of Cretaceous marls in Gebel Dhalal.—Gebel Krer.—Hamman Uset Range.—Country between Wadi Ethal and Gharandel.—Age of the Cretaceous beds.—Gypsumized Cretaceous rocks.—Due to action of water.—Metamorphosed representatives of *Gryphaea reticularis* limestone and Cretaceous marls.—*Nummulites gizehensis* bed never altered.—Cretaceous fossils from above localities.

#### Section V.—THE NUBIAN SANDSTONE .. .. . 154

Character of sandstones.—Previous views.—Russeger.—Figari.—Bauerman.—Hull.—General Description.—Gebel Hamman Saidna Musa.—Wadi el Araba.—Wadi Mokateb.—Wadi Budra.—Divisions in Gebel Dhalal.—Wind and sand action.—Constancy of beds.—Thickness of sandstone at Gebel Dhalal.—Origin of sandstone.—Walther's and Fourtau's views.—Aeolian *versus* fluvio-marine origin.—The age of the sandstone.

#### Section VI.—CARBONIFEROUS ROCKS .. .. . 160

Their extent.—Character of strata.—Russeger.—Figari.—Bauerman.—Ordnance Survey.—Hull.—Desert Sandstone.—Variations in thickness.—Overlap.—Detailed description.—Sandstone of Wadi el Akhdar.—Conglomerate of Wadi Sheqer.—Thickness in Gebel Habir.—Basalt cap and quartzite.—Quartzite in Debbet el Ramli plain.—Dolerite dyke of Wadi Baba.—Lepidodendron in sandstone.—Carboniferous of Serabit el Khadim.—Olivine Basalt cap.—Presence of limestone.—Wind action.—Iron oxide in sandstone.—Between Wadis Shellal and Sidri.—Boundary of Carboniferous sandstone arbitrary.—Reasons for boundary adopted.—Wadi Qenaia, etc. fault.—Carboniferous limestone.—Its extent.—Manganese and iron ores in pockets.—Wadi Meringa.—Carboniferous fossils.—Kidney ore.—Large fault.—Old workings.—Solution of limestone.—Old Mines of Wadi Halliq.—Ancient copper smelting.—Step-faults effecting limestone.—Rothpletz on age of strata.—Dolerite dyke.—Comparison with Carboniferous of Wadi Araba.—Sinai beds formed in shallower water.—Lower sandstone.—Gebel Serabit el Khadim.—Turquoise workings.—Thickness of sandstone.—Pockets of iron and manganese ore.—Evidence for overlap.—Shallowing after limestone period.—Lower Carboniferous age of sandstone.—Resumé of Carboniferous beds.—Fossils from Carboniferous strata.

#### Section VII.—TECTONIC GEOLOGY OF WESTERN SINAI .. .. . 171

Blanckenhorn's conclusions.—Divisions of Sinai tectonic geology.—*Folds*:—Two sets of folds.—Dominant one parallel to Gulf of Suez.—Dominant set broken by faults.—*Faults*:—Strike-faults.—Main West Sinai fault.—Throw of main fault.—Secondary faults.—Gebel Withr fault.—Smaller faults.—Gebel Markha.—Wadi Tayiba.—Wadi Nasb.—Gebel Abiad.—Step-faults in Gebel el Araba.—Gebel Baba.—Dip-faults.—

**Section VII.—TECTONIC GEOLOGY OF WESTERN SINAI (*continued*).**

Warm springs of Gebel Hammam Saidna Musa.—Gebel el Araba.—Wadi Ethal.—Trough-faults of Gebel Maghara.—Rift-valleys.—Raboisson and network arrangement of valleys.—Age of Gulf of Suez rift.

**Section VIII.—IGNEOUS AND METAMORPHIC ROCKS . . . . . 182**

Russeger.—Bauerman.—Holland.—Walther.—Raboisson.—Division of rock groups.—Three types of granite.—Extent of Igneous and Metamorphic rocks.

**I.—IGNEOUS ROCKS . . . . . 185**

1. Coarse red granite of Gebel Um Malaqa.—Gebel Sakhara, Abu Markh, etc.—Gebel Rashid, Khanasir, etc.—Gebel Tihi, Marit and Um Hash.—Sandstone in granite.—Gebel Um Sidri, Um Rieh, Teman and Temalli.—Recent sandstone on hills.—Gran Atud.—Gebel Um Shomer, Gebel Shiddiq.—Wadi Ilti.—Gebel Sawasia.—Gebel Um Sa, Gharba, Watia, El Elwi, and Sinai massif.—Gebel Serbal.—Gebel Yenna.—Gebel Retema and Hamra.—Wadi Barra and Lebwa.—Dykes.—Wadi Nisrin and Rumana.—El Araba range.—I b. Pink porphyritic granite.—Mode of weathering.—Coast range.—Gebel Ghub.—Wadi Mear.—Wadi Hebran.—Gebel Wirga, Ramuz, and Geba.—Gebel Um Esnan.—Country between Wadis Solaf and el Sheikh.—Between Wadi Shellal and Sidri.—I c. Grey granite.—Gebel At el Gharbi.—Wadi Um Malaqa.—Wadi el Sheikh.—Wadi Um Sheqer, etc.—Mixture of pink and grey granite.—2. Syenites and diorites.—Rare occurrence of syenite.—3. Dykes and veins.—Wadi Ilti compound dykes.—Quartz-felsite of Gebel Sawasia.—Wadi Hebran.—Dolerite dykes in country between Wadi Gharbi and el Sheikh.—Quartz-felsite dyke of Wadi Feran.—Dolerite, etc., dykes of Wadi Rummana and Rahaba.—Wadi Aqr.—Wadi el Akhdar.—Dykes in sedimentary rocks.—Dolerite dyke in limestone of Wadi Nokhel.—Gebel Hammam Farun.—4. Lava flows.—Gebel Maghara and Serabit el Khadim.—Age of this lava.—Lava of Wadi Tayiba.—5. Volcanic necks.—In Gebel Koli, etc.

**II.—METAMORPHIC ROCKS . . . . . 201**

1. Gneisses and schists.—Their extent.—Complex of metamorphic rocks.—Between Wadis Barq and Siq.—Character of gneisses and schists.—Garnetiferous rock of Gebel Matak el Barud.—Origin of the gneiss.—2. Metamorphic limestones and schists.—Gebel Um Esnan.—Abundance of garnet.—Succession in age of the rocks.—Probable sequence of events in West Sinai.

**Section IX.—ECONOMIC GEOLOGY . . . . . 205**

Granite.—Sand.—Iron and manganese ores.—Copper.—Bone-bed.—Coprolites.—Hydrocarbons.—Celestine.—Turquoise.—Distribution of workings.—Origin of the turquoise.

**Section X.—DENUDATION AND WEATHERING . . . . . 212**

Rainstorms.—Frost and snow.—Action of moisture containing carbon dioxide.—Goodchild.—Action of sand and wind.

## LIST OF ILLUSTRATIONS

---

PLATE	I.—	Feran Oasis .. .. .	Frontispiece
"	II.—	{ (a) Nagb Budra .. .. . (b) Lower part of Wadi Feran. .. .. . }	Page 41
"	III.—	Palm-Grove in Wadi Hebran .. .. .	" 79
"	IV.—	Freshwater Lake Deposits of Wadi el Sheikh .. .. .	" 102
"	V.—	General view of fault effects as seen from Nagb Budra .. .. .	" 145
"	VI.—	Sand-action in Gebel Dhalal .. .. .	" 168
"	VII.—	Dyke hill of Garn Atud in Coast plain .. .. .	" 187
"	VIII.—	Granite veining diorite, Wadi Mear .. .. .	" 190

---

### *Maps :—*

PLATE	IX.—	General topographical map of Sinai. .. .. .	End
"	X.—	Geological map of Western Sinai .. .. .	..

---

SECTION	I.—	From Gebel Abu Darba across Gebel el Araba and el Qa to the metamorphic area.
"	II.—	From Gebel Withr across Gebel el Asl to the metamorphic area.
"	III.—	From Gebel Nisisat across Gebel Abu Alaga to Gebel Meliha.
"	IV.—	From Gebel Usêt across Gebel Krer to Wadi Abu Qada.
"	V.—	From mouth of Wadi Tayiba across Gebel Sarbut el Gemel to Gebel el Ti.

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## PREFACE

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The area about to be described was surveyed during the five and a half months extending from the middle of October, 1898, to the end of March, 1899, by myself and by Mr S. T. Hardwick, who took charge of the topographical part of the work. The work was done by traverse up the various wadis crossing the plains, and by ascending commanding hills from which other points could be fixed and the country sketched in. The instruments employed were a measuring wheel, plane-table, and occasionally a tacheometer, while observations were taken every night, if possible, for latitude by altitudes of Polaris. The greater part of the country was done on sheets enlarged from the published maps of the Ordnance Survey of Sinai, on which the outlines of the main wadis were traced and the triangulation points used by the Ordnance Survey officers were transferred. The lower part of the Peninsula was surveyed on blank sheets. In the southern part of the district, work was very difficult on account of the boulder-strewn nature of the wadis, which prevented the use of camels in going up nearer the hills, and of the impossibility of crossing out of one wadi into another, thus entailing a loss of time in descending one valley to reach the next. In the middle of winter, too, the weather was often a hindrance on account of rain and snowstorms, the points often being hidden by clouds. In the spring on the coast-plain sandstorms and winds were of frequent occurrence, the former often causing the stoppage of work for a day, while the wind was often too strong to allow of the plane-table being set up on a hill-top, the compass being so affected that it would not settle. No trouble was experienced from magnetic rocks, as it was always possible to set the plane-table from the triangulation points.

This Report is divided into two parts, the first including a topographical description of the country traversed, a chapter on the Meteorology observed, and another on Natural History Notes. The second part is devoted to the geological structure of the country, including chapters on the tectonics of the district, economic products, and weathering agents.

We are indebted to Herr Guyot of Helwan, for plates I to V and VII illustrating this memoir. Plates VI and VIII were taken by the writer.

T. B.

Cairo, 1905.

**Note.**—The transfer of Mr. Barron to the Sudan has somewhat delayed the publication of this report. His lamented death at Port Sudan in February last prevented it being finally revised by him so that it is now issued subject only to some minor changes which were deemed advisable.

H. G. LYONS,  
*Director General.*

Cairo, August 1906.

# THE TOPOGRAPHY AND GEOLOGY OF WESTERN SINAI

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## PART I. TOPOGRAPHY.

---

In this report it is proposed to deal with the subject under the following divisions:

1. The plains such as El Qâ, El Markhâ and Debbet el Ramli.
  2. The sedimentary area :—
    - (a) Limestone plateau and parallel ridges.
    - (b) Low beach plateau to the north of Wadi Gharandel.
    - (c) Sandstone plateau.
  3. The main mountain mass:—
    - (a) Area north of Wadi Hebrân.
    - (b) Area south of Wadi Hebrân.
  4. An account of the meteorology observed.
  5. A short account of the vegetation, etc., as seen during the six months in which the party was at work in the Peninsula.
- 

### I.—THE PLAIN OF EL QÂ.

This plain, which extends from Ras Mohammed on the south to within about 6 kilometres south of Wadi Ferân, is bounded on the east by the central hill-range of the peninsula, which is here dominated by Gebel Um Shomer, on the west by Gebel el Araba and Hammam Saidna Musa as far as the village of El Tor, and for the rest of the way by the Gulf of Suez.

The northern part of it is drained by the Wadi el Wadi, which receives all the water which is not lost in the sands and gravel of the plain from Wadis Thaghadi, Thaghêd, El Abura, Geba, Hebrân and Meâr, as well as from the eastern flanks of Gebel el Araba. Although most of the water coming down these wadis disappears in the sands and gravels which form the eastern edge of the plain, a good part of it is eventually thrown out by the limestone which appears

on the western side, and forms a perennial stream in El Wadi ; in all probability also it is the source of the hot springs at the foot of Gebel Hammam Saidna Musa. From the level of Wadi Meâr, El Qâ is a level, gravelly expanse of wind-swept plain, there being practically no shelter from the weather, which in summer is uncomfortably hot, while in winter the winds sweep across it with relentless force, making the traveller muffle himself up in his warmest clothes.

Up this plain, parallel with the range of El Araba, goes the camel road from El Tor to Suez, which is the way by which the weekly camel-post conveys the mails to and from these towns. The telegraph line connecting these two places also follows this road pretty closely. Near the head of this plain, another path joins the main Suez road, forming a second and less frequented route from that town by way of Wadi Mokateb and Maghara.

Sikket Abbas  
Pasha.

Immediately on leaving the bed of El Wadi where it makes its way seawards close to Gebel el Araba, a well-made carriage road is seen running in a north-easterly direction towards Wadi Hebrân, which it enters and follows up to its head. This is called by the Bedawin Sikket Abbas Pasha. Since it was made, the torrents of winter have carried a good part of it away in many places, especially in Wadi Hebrân. From the guides it was learnt that this road was made by Abbas Pasha by means of forced labour ; soldiers seized the people and compelled them to work by whips ; and in the course of its construction, numerous persons died from the barbarous treatment received. This road was made from El Tor to Gebel Musa where the Pasha at first proposed to build a summer residence, but finding that the hill was so steep, and the work of making a carriage road up it so difficult, it was abandoned in favour of Gebel Qasr Abbas Pasha or Samr el Tinia of the Ordnance Survey, on the top of which the ruins of the palace still stand.

To the south of this road the plain is covered with low mounds of fine clay, sand and igneous pebbles, low hills of limestone and gypsum, and on the east side mounds of boulders of granite and other igneous rocks. To the south of El Tor it becomes a waste of rippled sand mixed with boulders, which, as Ras Mohammed is neared, becomes dotted with outlying patches of igneous hills. On the sea-coast a strip of salt-bearing clay of varying width persists from the southern point to the neighbourhood of Gebêle. Before reaching this village this salty soil was dotted over with mounds of sandy clay, each covered with a growth of tamarisk bushes, or a spiny bush yielding a red berry of a pleasant acid flavour called "Ghargad."

In width this plain varies from 3 or 4 kilometres above the neck of Ras Mohammed to 36 at its broadest part to the south of El Tor, while between Gebel el Araba and the central hill mass, it is 26 kilometres opposite Wadi Hebrân.

At the foot of Gebel Hammam Saidna Musa there is a large grove of date palms, as well as numerous gardens belonging to the monks of the Greek church at El Tor, and from the fruit they brew various kinds of liquors. Between these gardens and the town there is another expanse of sandy ground dotted with mounds bearing "ghargad" bushes.

The town of El Tor stands at the head of the bay of that name on El Tor a small mound of raised beach, and is surrounded on the landward side by a strip of salty clay which in winter is practically a marsh. It is mainly composed of Arab houses, besides which there is a Greek church and monastery, a post and telegraph office and two consular agencies for Russia and Germany; other countries used to be represented but have now withdrawn. There is no regular service of steamers from Suez except during the pilgrim season, the town being only occasionally visited by the coast-guard cruiser, or a small sailing-boat which had been engaged to bring down grain and other necessities for the inhabitants.

A little over two kilometres to the south of the town of El Tor Qrum. stood the native village of Qrum in its grove of palm trees. Buildings connected with the Quarantine service have now been built on this spot.

About 4 kilometres further south from Qrum stands the fishing Gebêle. village of Gebêle amongst a few palm trees. It consists only of a few straggling houses of the poorest description, and the people seem to be in great poverty.

#### PLAIN OF SÊH SIDRI AND EL MARKHÂ.

This plain, which extends from latitude  $28^{\circ} 48' N.$  to near latitude  $29^{\circ}$  along the coast of the Gulf of Suez, is from 20 to 21 kilometres long, and varies from 2.5 to 7 kilometres in width. It is bounded on its south-east side by the limestone hills of Gebel Nisisât, on the east by the gravel and gypsum plateau and the limestone hill of Gebel Hadûd, the low hills round the mouth of Wadi Baba, and the high gneiss hill-range of Gebel Samra, and on the north by the limestone plateau of Gebel Markhâ. Along the foot of the hills on its eastern

side, mounds of igneous and limestone gravel occur mixed with sand, which, as Gebel Hadûd is approached, give place to blown sand banked up against the lee of this hill, in many cases reaching to its summit, thus offering an easy means of descent from an otherwise impracticable precipice. The surface of this plain slopes gently towards the sea, being covered in the neighbourhood of Wadi Baba with numerous boulders of gneiss, granite and other igneous rocks. Opposite the mouth of the above-mentioned wadi, a sort of delta seems to have formed of the debris brought down by the torrents, which has caused a bifurcation of the bed, one arm going in a westerly direction to the sea, while the other flows north-west and joins the other drainages from the hills on the north-east of the plain, entering the sea near its northern boundary. Across this plain several good camel-tracks are met with, the first, and perhaps the most used, being that which runs almost due south towards Wadi Ferân and thence to El Tor; the second crosses it diagonally to the mouth of Wadi Baba, up which it passes, and thence over Naqb Budra to Maghara, Wadi Mokateb, etc. From both these roads branch-tracks run off to El Markhâ, a pool of water occurring at the foot of Gebel Markhâ. The water is slightly brackish but drinkable, and seemed to be able to water a fairly large number of camels. Close by it is a young palm tree round which seems to be a favourite camping ground of the Bedawin who travel this way. Another well occurs in the gneiss hills to the east about one kilometre up a small wadi. It is not perennial, and yields water only after rain; it is called Bir Dhafâri.

This plain, except for a few stunted seyal trees scattered over its surface, is a very barren place, and offers little food for any animal except after the winter rains. From it a good view is obtained of the hills through which Wadis Baba and Shellâl make their way to the plain. These hills, with the small caps of dark red sandstone on their summits, present a very varied contrast of colour. In the foreground is the yellowish, sand-covered plain; while forming the foothills of the main range are the limestone ridges, behind which come dark-red granite, the dark-grey gneiss, and the red sandstone capping all. Further to the south-east can be seen the fine pink range of which Tatar el Dahami forms the highest point.

#### DEBBET EL RAMLI.

This plain, which lies between 600 and 700 metres above sea-level, extends from Wadi Siq on the south-east to Wadi Hamr on the

north-west, a distance of 52 kilometres, and has a maximum width of 6 to 7 kilometres. It is bounded on the north-east side by the El Ti escarpment ; on the south-east by Wadi Siq ; on the south and the south-west by the sandstone bordering Wadi Suwiq and the plateau through which Wadi Baba cuts its way, and on the west by Wadi Hamr.

It is drained by the Wadi Siq on the eastern side, and by the Wadis Garf and Bêda on the opposite side, the water finding its way through Wadi Baba to the sea.

Strictly speaking, this is not a plain in the proper sense of the word, but rather an open piece of country resulting from the attrition of the sandstone rocks, small hills of which, capped by basalt or some hard bed, still stand up in the midst of the debris of the adjacent rocks. Against these knolls, huge banks of sand have been piled up, and gradually tail off into the general level of the plain. This, then, is the origin of this plain, viz., the wearing down of the sandstone at the foot of the El Ti scarp, and the removal of it by the wind and piling of it up in another place. Especially is this the case on the south and south-west sides, where the sandstone beds disappear in the general slope of the plateau under these mounds of sand. The slope of the plain, following that of the sandstone beds, is towards the cliff of El Ti, and its lowest point is the wide basin-like bed of Wadi Garf, which runs along the foot of this escarpment for about 16 kilometres, and then bends south-west into Wadi Baba.

On its eastern half it consists at the surface of firm, well-packed gravel and sand, containing numerous pebbles of quartz of various colours, and affords excellent ground for walking upon. But the western half is quite different, consisting either of soft loose sand which is extremely tiring to walk upon, or of bare rock surfaces.

The eastern half of this plain, after the winter rains, affords a fair amount of green food to the numerous flocks of sheep and goats belonging to the Bedawin in this part of the country, in the form of one of the trefoil family (*Trigonella stellata*), which was seen growing abundantly on the firm sand of dunes. The other half, except in the beds of the wadis where various shrubs and plants abound, is absolutely barren.

Across this plain runs the northern road from Suez to the Convent at Gebel Musa, passing up Wadi Shêqer and across the plateau of Elwi el Agramia, through the pass of El Watia in Wadi el Sheikh, and on to its end in Wadi el Dêr.

## 2.—THE SEDIMENTARY AREAS.

Standing on a commanding point like the northern end of Gebel Serbâl, the contrast between the plains and sedimentary areas, as distinguished from that of the main mountain area, is very clearly seen. While the plains on the one hand have few features to relieve their monotony, the sedimentary area rises in a series of ridges and rounded hills, which present numerous problems of geological interest. In this district, as in practically every other, the topographical features owe their origin to its geological structure. For instance, in the coast ranges of El Araba and Qabeliat, the parallel ridges which compose them are the direct outcome of their geology; the wadi which drains them is due to the erosion of the soft Nubian sandstone; while the low parallel scarps between it and the main cliff of Gebel Araba proper, are produced by the wearing away of the softer marls which alternate with limestone beds, the whole having been tilted by earth movements.

To this latter cause is due the absence of any of the plateau-features which usually characterise sedimentary areas in this part of the globe, the beds having been so dislocated by faults as to have lost their usual horizontal stratification.\* On the other hand, the main mountain mass presents bold, rugged peaks towering one above the other in massive grandeur, their sides seamed by steep-walled, narrow gorges down which roll the torrents produced by the heavy thunder-storms so frequent in this district, roaring and leaping over numerous cascades of polished rock, and carrying trees, boulders, and everything before them.

### (a) LIMESTONE PLATEAU AND PARALLEL RIDGES.

Gebel  
Hammam  
Saidna Musa.

*Coast ranges of El Araba, Qabeliat, etc.*—Commencing from the south at Gebel Hammam Saidna Musa, this hill presents a steep scarp facing El Tor, gradually lowering until it runs to earth in El Wadi. On its seaward side it presents a steep cliff which is almost unscalable, from which it slopes gently, by a series of small steps, eastward to the plain of El Qâ. Along its south-west side remains of Christian chapels and hermits' cells were seen excavated in the rocks. At the foot of the scarp facing El Tor several hot springs issue from the hill, and are led into the gardens owned by the monks for purposes of

Hot Springs.

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\* These remarks do not include the plateau of El Ti, as that was not explored.

irrigation. There are, however, the remains of ancient baths, some of which are still used by the Arabs during their visits there. These springs are believed by the Bedawin to have remarkable healing powers, and are used by them for various skin diseases, as well as for various rheumatic ailments.

This hill is separated from another—Gebel Abu Suwêra—by the wadi of that name. Its character is similar to the last, and it is capped by a coral limestone which gives it a rough, rugged top. This hill is bounded on the north by the Wadi el Araba, and is connected by a ridge with Gebel Naqus.

Wadi Abu Suwêra takes its origin about the middle of this range, and descends very rapidly through a narrow gorge in the sandstone, often of wonderful wildness, to the sea. A camel path passes over the ridge, at first following the wadi, but later on, owing to the latter descending over small precipices, has to adopt a zigzag course down the hillside.

At the point where this wadi emerges on the sea-coast is a small palm grove, in which a spring of water occurs only a few yards from the sea shore. The water from it was said to have strong aperient qualities.

From the plain of El Qâ the road into Wadi el Araba goes up a small drainage called Wadi el Araba el Sogheira, and crossing the ridges known as Batn el Araba, descends a steep sand slope in a pass near Gebel Naqus.

The sand on this slope has been reported by various travellers to give out a booming sound like that of a distant bell, but when crossed by the writer, either owing to unfavourable physical conditions, or to its having been disturbed shortly before, this phenomenon was not observed. That it does occur is undoubted, and in Part I. of the Ordnance Survey of the Peninsula of Sinai, pp. 131-134, a detailed account of experiments and observations made on this sand-slope is given. Musical Sand.

From the point where this pass enters Wadi el Araba proper, the true parallel character of the ranges becomes established. From the place where this wadi enters the sea a range of igneous rocks commences, at first low and narrow, but gradually becoming higher and wider. The chief rock in this range was a reddish granite, on the landward side of which lay red sandstone.

The total length of the range is between 39 and 40 kilometres. At its southern end it is called Gebel Ghub, but the name for the whole range is Gebel el Araba.

About 26 kilometres further north this range is breached by Wadi el Araba. In order to avoid confusion it is here necessary to explain that the two outlets to this wadi are in all probability due to a dip-fault, which at this point has apparently broken the line of drainage in two, and by the lateral shift, as well as the throwing down of the beds, has diverted the water through the opening in the coast range. This seems the only explanation, as the course of the southern part of the wadi, being parallel with the strike of the beds, was the easiest possible, and unless some powerful agent opened a way through the igneous ridge, the water would never attempt it while it had this much easier course open to it.

Between these two openings, but nearer the northern one, is Gebel Abu Hoswa, one of the highest points of the range, being 692 metres above the sea. Its eastern flank, as well as a large part of the range, is covered by blown sand, which in some cases has reached the top of the ridge.

At its southern end it drops right into the sea, there being not even the width of a path along the shore. As it is followed north, however, a small strip of beach is gradually interposed between it and the sea, and between the northern branch of the wadi and the end of the range there is a good road on the sea-coast.

Its highest and best-marked peak is called Gebel Abu Darba, which is used as a landmark by navigators on this coast. It stands up from the rest of the hill-mass as a sharp, jagged peak, and is seen from the landward side for a good distance as well.

At the northern end of the range where it gives on the wide plain at the mouth of Wadi Ferân, the granite hill is almost buried in blown sand. The seaward side of this ridge is very steep and abrupt, while towards the land it presents a gradual slope.

**Batn el Araba.** The part of the coast-range known by this name is the series of low parallel ridges which lie between the igneous hills and the limestone ridge bordering the plain of El Qâ. They gradually decrease in height as they approach the latter.

**Limestone Range.**

This extends from the point where the road through the pass at Gebel Naqus enters the range up to the point where Wadi Qabeliat breaches it, a distance of about 40 kilometres. On its western side it presents a sheer, unscalable escarpment, while to the eastward it slopes at a gentle angle until it loses itself in the plain of El Qâ. Its continuation is known by the name of Qabeliat.

The whole of this range, except the eastern slope of the limestone ridge of El Araba, is drained by the Wadi el Araba, which passes out

at three points into the sea. The first opening is at the southern end of the igneous range ; the second at the middle where it is broken by the lateral shift of the rocks ; while the third is at the northern extremity of the coast-range. The middle branch of this wadi is the most important, as it receives drainage from north and south, as well as the water collected by Wadi Qabeliat which drains the country to the north-east.

This hill forms the head of the ranges which have been classed under the term Gebel el Araba. It forms a round, flat-topped mass presenting a steep scarp to the sea, with a low subsidiary plateau at its foot, and sloping gently down on its eastern side towards the plain of El Qâ. It is mainly composed of limestone, but patches of gypsum occur on its eastern flank, and the foot-hills on its seaward side are largely of sandstone. In the small wadis which cut this low plateau, large dunes of blown sand occur, making climbing very difficult, although once the slope is mastered, they make what would be otherwise dangerous or impossible descents easy.

Gebel Qabeliat  
(Mountain  
fronting the  
sea).

Stretching away from the foot of the low plateau towards the sea is a plain much cut up by water channels and covered by boulders of igneous and other rocks brought down by the Wadi Ferân.

#### *Sedimentary area east of El Qâ, etc.*

Starting from the south, the first patch met with is that of Gebel Safariat, a mass of highly tilted and dislocated strata opposite the mouth of Wadi Hebrân. Topographically it is not of much importance, although of great interest geologically.

Gebel Safariat.

Passing northwards across the plain towards the main plateau, the first part reached is Gebel Asfar, so called from its yellowish colour. It stands in the angle formed by the sedimentary plateau where it abuts on the granite foot-hills of Gebel Serbâl. This hill presents a sheer cliff of 200 metres or so on its south and east sides where it overlooks the junction of Wadi Geba (the valley of pools) with that of Wadi Raqqa, the latter separating the igneous from the sedimentary rocks. At its mouth it is a series of smooth water-worn precipices at the foot of which are fairly large pools of water. From its mouth it is unscalable, but it can be descended with care. This narrow gorge presents some very rugged scenery while it lasts ; but a little distance from the mouth the wadi suddenly opens out into a wide, sandy bed with open country between it and Serbâl. Above the gorge, according to the information supplied by the Bedawin, the name of the wadi becomes

Gebel Asfar.

Wadi Raqqa.

changed to that of Geba. Into it flows Wadi Um Lahm which heads in Gebel Um Lahm.

Wadi Geba is a fine broad valley abounding in plants of various kinds, on which numerous camels and goats browse, it being reached by a path across the low hills from Wadi Abûra. Several well-grown seyal trees were also seen in this wadi.\*

Wadi Abûra.

Passing in a north-westerly direction up the plain, the next wadi met with is that of Abûra (the place of crossing), so-called because the Bedawin say there is a path from this wadi across Serbâl to Ferân. This wadi rises in Gebel Tigellîa, and passing through the ridge of limestone which forms the eastern boundary of the plateau, winds through the low hills in a broad open course, until it enters the plain of El Qâ.

Not far from its mouth is a well of good water with a few palm-trees round it, and some ruined houses near by. Numerous seyal trees also occur in this valley.

Wadi Abu Gurdi.

Quite close to this wadi is that of Abu Gurdi. It is only a short valley heading a little distance up in the plateau. Its right bank is formed by a steep escarpment of red sandstone and marl, the left bank being mainly limestone and marl.

Wadi Thaghêd.

This is only a short valley which heads in the small plateau to the west of the previous wadi. Here occur a few palms, and water which is slightly salt.

Wadi Thaghadi.

About a kilometre north of the last wadi occurs that of Thaghadi. —so called on account of the bad dates produced by the palms here which when eaten give a feeling of throttling (Thaghad). It enters El Qâ about 18 kilometres below Wadi Ferân. At its mouth, which is narrow, is a grove of palm-trees with several wells of slightly brackish but drinkable water. These are much frequented by the Bedawin on their way to and from Suez, and form one of the main places where their qirab (water-skins) are refilled. The wadi is entirely blocked by these trees, which extend for about 750 metres. Higher up it widens out, and later on divides into two which go north and east respectively, the former, being the longer, ends in the limestone hills, while the latter heads in the ridge close by. The sides of the wadi are made up of red sandstone for part of its course, this rock being broken up into curious and fantastic knolls, peaks, and ridges which are very picturesque.

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\* There seems to have been a confusion of names in the wadis mentioned; the lower part of the wadi ought undoubtedly to be called Geba, and the upper part Raqqa (the valley with cultivated sides).

A foot-path is said to go up the eastern branch of this wadi and across the plateau to the west side of Serbâl.

From this wadi until Wadi Ferân is reached there were no valley of importance. The following are their names: Wadi Abiad which comes from behind Gebel el Abiad, a steeply tilted hill of limestone; Wadi Abu Qallam, and Wadi Abu Themâm, which come out of the low plateau of Cretaceous marls; and finally, Wadi Khadahid runs down from Gebel Khadahid into Wadi Ferân.

The plateau here is made up of alternate ridge and valley, or anticline and syncline. These ridges extend up to Wadi Thaghadi, and are cut off by what seems to be a small roll of the beds, the upper limestone being removed and leaving a low plateau of marls sloping towards El Qâ. These are bounded on this side by Gebel Abiad and Khadahid, which are more or less rectangular masses of limestone standing up out of the plain and dominating all the surrounding ridges. The Plateau.

Out in the plain, forming the head of El Qâ, are a few low hills of conglomerate and limestone, the chief of which is Gebel Ekmi, and these slope gently to Wadi Ferân. Gebel Ekmi.

The southern side of Wadi Ferân is formed by a mass of limestone sloping towards El Qâ, and ending on its east side in a vertical escarpment along the foot of which runs the Wadi Asl heading in Gebel Asfa. This plateau in outline is rectangular in shape, and ends in a spur where it connects with Gebel el Rigma. The main hill-mass is called Gebel el Asl, while the spur bears the name of El Asfa. This mass of limestone forms the northern boundary of the low-lying tract of marls previously mentioned, a wadi which heads in Gebel el Asfa and joins Wadi Khadahid separating the two. South side of  
Wadi Ferân.

Between this limestone plateau and the next ridge there is a lower strip of marls, which ends up in a point at Gebel el Rigma on the south, but runs round the base of the ridge on the side of Wadi Ferân. This ridge is steeply inclined to the west, and presents a steep escarpment to the east, being connected by a series of isolated knolls with the main plateau to the north-east which lies against the igneous hills. On the side of Wadi Ferân it is continued by foot-hills of marl down the boundary of the gneisses opposite Wadi Nisrin.

Turning to the north side of Ferân the scenery is very similar to that on its southern side. There are the same foot-hills of marl, above which rises the steep scarp of the limestone, forming a rectangular mass called Gebel Mokateb which slopes west and north-west, and eventually running off in a northerly direction. The ridge of marls ends in Gebel Abu Alaqa, and establishes a watershed between Wadi Sidri and Wadi Ferân. North side of  
Wadi Ferân.  
Gebel Mokateb

*Plateau between Gebel Mokateb and Gebel Withr.*—This plateau is bounded on the north by Wadi Sêh Sidri and on the south by Wadi Ferân. It consists of a mass of pinkish white limestones, having Gebel Abu Alaqa on its north-east corner, and draining by small wadis into the previously-mentioned main drainage lines. The main drainages falling into Wadi Ferân are the Wadi Khrêsa, which collects the water from Gebel Mokateb, Abu Alaqa, and the northern part of the low plateau; and Wadi Withr, which receives the water from Gebel Withr and the southern edge of this limestone mass. On the Sêh Sidri side there are several short valleys, among which are Wadis Khrêza, Morr and Withr.

Gebel Abu  
Alaqa.

This is a hill rising with precipitous sides from Wadi Sêh Sidri. At its base on this side it consists of granite; but on its eastern side it starts with foot-hills of red sandstone, presenting vertical scarps difficult of access; above these are the steep-sided marls; while, capping all, and accessible only at certain places, are beds of flint conglomerate. Having reached the summit, an excellent view of the surrounding country is obtained. This hill is one of the trigonometrical stations of the Ordnance Survey, and stands a little over 240 metres above sea-level. Towards the west it drops down steeply to the low limestone plateau.

Passing across this plateau it was found that a good deal of blown sand has been laid down in the depressions, apparently largely derived from the limestone itself. Going westward a lower plateau of gypsum is crossed, called Gebel Morr, and about 3 or 4 kilometres further west Wadi Withr is reached, the scarp of this gypseous mass forming its eastern side. This plateau of gypsum and limestone is continued on the north side of Sêh Sidri for some little distance, the former coming to an end on the edge of El Markhâ. The total extent of this limestone plateau is 19.5 by 9.5 kilometres, while that of the gypsum is 13.5 by 3 kilometres.

Wadi Withr.

This wadi drains both to the north and south. From the Sêh Sidri side it is difficult going on account of the amount of sand in its bed, and towards its watershed it has to be abandoned for the plateau on account of the small precipices in its course. The part draining southwards is much more open, beginning in a small plain which gradually narrows to a few metres wide as it descends towards Ferân, again opening out after it has made its way through the gypsum into the gravel area on the side of the above-mentioned wadi. This wadi receives all the drainage from Gebel Withr, and along it is the camel track followed by the post-runner between Suez and El Tor.

This is a longitudinal ridge running from the mouth of Sêh Sidri to Gebel Withr. that of Ferân for a distance of 19 kilometres and having an average width of 2.5 kilometres. At its northern end it presents a sheer scarp on its western side facing the Gulf of Suez, but towards Wadi Ferân a series of low foot-hills run out from it ending in Gebel Khadid el Dhib (the trench of the wolf). Towards Wadi Withr it falls with a slope of about 10°. At its northern end it is divided into two by Wadi Nisisât, the western limb being named Gebel Nisisât.

The telegraph line from El Tor via El Qâ to Suez follows the narrow strip of beach from Wadi Ferân to El Markhâ plain, and then across the latter to the mouth of Wadi Tayiba, where it leaves the coast.

From the mouth of Sêh Sidri to that of Wadi Baba there is little of Gebel Hadûd. any topographical interest. The low marly and gypseous plateau runs up until it reaches Gebel Hadûd, a limestone hill (probably so called because there are a few veins of tachylyte in it) which presents a bold escarpment to the west, against which blown sand is banked up almost to its summit. The continuation of this hill forms the eastern boundary of El Markhâ at this point ; while to the east, lying in a hollow in the limestone, are some clays, marls and conglomerates with a sharp ridge of limestone dividing them from Wadi Shellâl.

*The plateau of El Markhâ.*—This plateau forms a part of the great mass of limestone which extends up to and beyond Wadi Tayiba, and varies from 9 to 16 kilometres in width. It consists of a mass of limestone which has been let down by a fault against the crystalline rocks of the centre of the peninsula. Opposite El Markhâ, near the "Ein" (well) of that name, there is a depression caused by a secondary fracture. Passing round the sea coast, which here is almost covered at high tide, a bold escarpment of flinty limestone is present at Gebel Nokhel near the mouth of the wadi of that name. This wadi Gebel Nokhel. drains practically the whole of this side of the plateau. Going northward the road leads over a series of rocky ledges across the headland of Ras Abu Zenîma, so-called from a saint of that name who was buried there. From this point the road runs along a low, gravelly beach, called El Markhîa, to the mouth of Wadi Tayiba.

From the place where the limestone approaches the shore, a dyke is seen crossing the plateau in an east of south direction, and running out to sea. This is seen after crossing the terraced limestones near Abu Zenîma, where the limestone gives place to the marls, and the country becomes lower.

As the mouth of Wadi Tayiba is approached a conspicuous black ridge standing steeply tilted towards the sea attracts attention on account of its unusual appearance. This is an interbedded lava in the newer deposits of the sea-coast.

*Wadi Tayiba.*—The entrance to this wadi is very grand, the contrast between the dark bed of lava with the reddish conglomerate and white limestone being very striking. This sheet of lava forms as it were the gate posts of the entrance to the valley. At this point the wadi is only 45 metres wide, and is bounded on either side by vertical cliffs of Cretaceous limestone. About a kilometre from the mouth a few palm trees are seen, a sure sign of water. The road is excellent, being smooth and firm under foot, and where gravel is absent the bed of the wadi is made of a smooth floor of limestone. As the valley is ascended it gradually widens as the cliffs on either side become lower, until it is about 180 metres in width. A little over 2 kilometres from the mouth, and while the wadi is still narrow, a small grove of stunted palm trees and tarfa bushes is met with, near which are several pools of brackish water, unfit for drinking purposes, except in extremity, but useful for washing. On the right and towering above the wadi is a reddish hill with a prominent black band in it, which on being climbed proved to be part of the same conglomerate with interbedded lava that was found at the mouth of the valley. This was seen to extend about 2.5 kilometres eastward, and was connected with the dyke mentioned as present in Gebel Nokhel.

From this hill it was seen that the marls were disappearing to the north-east under a ridge of limestone, which gradually fell away to valley level in the neighbourhood of a prominent hill called Sarbât el Gemel.

From the springs, palms and tarfa bushes the road runs up the wadi for 3 or 4 kilometres between gradually lowering hills until it comes to the mouth of Wadi Shebêka where Wadi Tayiba proper ends. At this point it splits up into three branches; the most northerly is Wadi Shebêka (so called because of the labyrinth of wadis of which it is made up); the middle member, Wadi Mâdat el Melh, which loses itself in the low limestone hills to the north-west, is only practicable for lightly laden camels; and the last and most easterly, Wadi Hamr (so called from its red colour), which is the main drainage line, is also the road followed by travellers going to Gebel Musa by the northern or central routes.

**Wadi Shebêka.** This wadi is only about 3.5 kilometres long, and drains the country between Wadi Ethâl and Tayiba. The Suez road turns up this wadi,

the telegraph line likewise following the same course, and after crossing some low country descends into Wadi Ethâl.

Leaving the mouth of Shebêka and passing up Wadi Hamr (here a Wadi Hamr. fine open valley with retem, shia, sakran and other plants), the road runs east between low limestone cliffs 10 to 15 metres high. The floor of the valley is smooth, and makes excellent going. About 3 kilometres from its mouth, it is crossed by the dyke previously mentioned, which at its point of contact with the limestone has blackened it by the development of hydrocarbons. On the sides of the wadi, masses of boulders and gravel occur, on which patches of the plant called Hamad or Hamatha (*Rumex vesicarius*) by the Bedawin grow in great luxuriance. This is a succulent plant with reddish hollow stem and heart-shaped leaves, much sought after by the camels, which eat it readily. It is also eaten by the Bedawin.

About 5 kilometres from its mouth, Wadi Hamr receives its main tributary, Wadi Ibn Sakkar, from the left. This valley, which gets its name from an old legend concerning some man who became insane and lived here on the plant Sakran, is 12 to 13 kilometres long, heads in the sandstone plateau at the foot of El Tî, and receives part of the drainage of Sarbût el Gemel. Opposite its mouth Wadi Nokhl enters from the right, a small and unimportant feeder. Wadi Ibn Sakkar.

At this point the sides of the wadi begin to disappear, and its bed widens out to over a kilometre in breadth, this continuing up to Sarbût el Gemel. Speaking correctly, there is no proper boundary, as the country is practically a plain at this point, with a few knolls of limestone or detritus scattered over it.

This is a bold ridge of limestone and flint conglomerate rising Sarbût el Gemel. 366 metres above the valley, and resting against the sandstone, which forms the country between it and the plateau of El Ti. It has been let down by the main line of fault, which has thrown down the whole of the plateau to the south against the older crystalline rocks.

After passing this ridge the valley enters the sandstone country, and contracts to about 100 metres in width, being bounded by low cliffs on either side. In this area the sandstone presents the scoriaceous appearance so well known in other districts, but the most remarkable phenomenon is the well-rounded appearance of the hills, due to wind and sand action. So well-rounded are they, that at a distance they might be mistaken for granite knolls, so closely in shape and colour do they resemble the latter. About one kilometre below Wadi Qarûra, Sinaitic inscriptions were seen on the rocks.

Seven kilometres from Sarbût el Gemel the mouth of Wadi Qarûra Wadi Qarûra. is reached, and here the road bifurcates, the central path to Gebel Musa

following this valley, while the northern route goes up Wadi Hamr to where it heads in Debbet el Ramli, and thence across this plain. The course of these paths will be described in detail later on.

At this point Wadi Hamr was left, and a rugged path followed over several passes and very bad ground indeed, a road, that until one knows the capabilities of the camels of Sinai, would have been the last to be attempted. This road is as a matter of fact only used for riding camels, but thanks to the good and careful management of the drivers, all the camels, heavily laden with baggage though they were, reached Ras Ethâl in safety.

Ras Ethâl.

Near the head of Wadi Ethâl the line of division between El Tî and the low plateau to the west becomes obliterated, the two being connected by a line of flat-topped hills bearing the names of Gebel Madsûs and Abu Dêmat. These consist of Cretaceous marls with sandstone at their base, against which the limestone has been let down by the same line of fault as that met with at Sarbût el Gemel.

For about 4 kilometres from its head this valley is impracticable for camels, on account of the boulders and small precipices in its bed, so the way runs up over the flank of Abu Dêmat, over beds of crystalline limestone rendered slippery and dangerous by sand-action.

At the point where the camel path struck the wadi there were a few well-grown palm-trees, and one or two fine seiyals, as well as good water.

Gebel Krêr.

On either side of the valley the ground slopes down from Gebel el Tî towards the west. Gebel Abu Dêmat ends in an escarpment facing west, while the continuation of Madsûs runs to valley-level opposite Wadi Hiâla, a tributary of Wadi Qâda. Above this depression rises the steep escarpment of Gebel Krêr, a narrow limestone ridge cut off by a fault from the main mass; it is a reduplication of the main hill-range of that name.

Further to the west, between Ethâl and Wadi Usêt, the country is broken up by masses of gritty limestones, but its general character is that of an open, easily-traversed district, the wadi being bounded by low mounds, and rarely, if ever, having any distinct walls until near the Suez road, which crosses it about 5 kilometres from its mouth. At this point occurs a salt marsh with trickling streams of very brackish water, near which were a few stunted palms and tarfa bushes. The water is evidently thrown out from beneath the marls which occupy this hollow, by the hard limestone forming its floor. In winter a considerable quantity of water must occur here, judging from the quantity of salty mud lying around.

Below this the wadi begins to contract, and a little over a kilometre further down receives a small affluent, Wadi Krêt, which drains the eastern slope of Gebel Usêt. Beyond this junction it narrows rapidly and becomes a winding ravine 40 to 80 metres wide. About 2 kilometres further down, it narrows still more to a deep, wild gorge, cutting through the flank of Gebel Usêt. It is altogether impassable for camels, and very difficult for foot passengers; in many cases it is only 10 metres wide, and bounded by almost sheer cliffs of limestone of great height.

Wadi Ethâl  
impassable  
near the coast.

Returning to the Suez road where it crosses the wide, shallow syncline which lies between the Hammâm Farûn-Usêt range and Gebel Krêr, it is seen to skirt the east side of the salt marsh above-mentioned, and keeping along the bare, dry plain bears in a north-westerly direction towards Wadi Usêt. On the east it is bounded by a low ridge and mounds of marly beds, while its western side is formed by a low subsidiary escarpment of gritty limestone of a dirty brown, earthy colour capping the whitelimestones of Gebel Usêt. About 4 kilometres north of Wadi Ethâl, the water-parting between it and Usêt is reached; and about half a kilometre further on, is a shallow water-course which collects the drainage from the country on either side and carries it down into Wadi Usêt, 7.5 kilometres north of Ethâl.

Road between  
Wadi Ethâl  
and Wadi Usêt.

*Wadi Usêt.*—At the point where the road strikes this wadi there are one or two stunted palm trees as well as shrubs of gharqad, tarfa and retem, while just to the east of the road is a single palm, at the foot of which are some brackish springs, seldom used because of their proximity to the better supply in Wadi Gharandel. At this point the valley is broad and deep, descending through the maze of low hills from Gebel Krêr in which it takes its origin. Between it and Wadi Gharandel there lies a large mass of marls, etc., covered by a cap of gypsum.

Below the Suez road this wadi suddenly narrows as it enters the limestone ridge of Gebel Hammâm Farûn, cutting its way through the flanks of that hill by a picturesque gorge to the sea. This gorge, which is 3 kilometres long, winds its way between cliffs 20 to 30 metres high, the crest of Hammâm Farûn towering above it to the south. It is 20 to 30 metres wide, and its bed for a large part of the way is made of solid rock, water-worn and polished, and difficult to walk upon. At different points, too, the wadi takes a sudden drop over a hard ledge of rock, these various obstacles rendering it impassable to laden camels; while it is very difficult for heggin (riding-camels). About a kilometre

Wadi Difficult  
on account of  
small  
precipices.

from its mouth the wadi leaves the limestone, and opens out between low hills of marl and conglomerate, after which it debouches on the coast-plain and makes its way to the sea.

Hammâm  
Farûn-Usêt  
Range.

Having described these two wadis, the coast-range of Hammâm Farûn and Usêt comes next in order. This range extends from a point 2.5 kilometres south of Wadi Ethâl to the edge of Wadi Usêt, a distance of 12 or 13 kilometres. On its west side, towards the Gulf of Suez, it forms a sheer precipice up to the vicinity of the hot springs of Hammâm Farûn, the sea washing its foot, and not even the breadth of a path being left uncovered. It is thus impossible to observe this range from the west except from the sea. To the east the ridge falls away gradually, dipping about 10° in that direction, but gradually becoming less steep on the flanks of Hammâm Farûn. On the southern half of the ridge, Gebel Usêt stands up in a well-defined, round, pointed peak, which is seen for a good distance in the country round about. It was used by the Ordnance Survey as a triangulation station on that account. In climbing it, the part at the top is very difficult, owing to the hard flinty limestone beds of which it is composed forming almost vertical ledges, on which footing was rendered very insecure by the quantity of angular gravel covering them. On its south side the hill falls away in a series of vertical cliffs towards Wadi Ethâl.

Gebel Usêt.

Gebel  
Hammâm  
Farûn.

The northern end of the above-mentioned range is generally known as Gebel Hammâm Farûn, but the Bedawin guides informed us that the whole range was really called Usêt. It forms a bold limestone bluff 479 metres high, facing the north-west and was used as a latitude and azimuth station by the Ordnance Survey. Here there occur several hot springs which gush out at the foot of the cliff or even out of the sand itself. When approaching these springs from the north, a sickly smell of petroleum is discernable over a kilometre off, which rises from the water. The temperature of the water, according to the determination of the Ordnance Survey, is 160° Fahrenheit, or 71°C. The following is an analysis of the water taken from the Ordnance Survey Report :

Hot Springs.

Chloride of sodium.....	73.215 %
Sulphate of lime .....	6.720
Sulphate of magnesia ....	20.065
	<hr/> 100.000

Specific gravity at 60° F. 1007.3, water being 1000.  
Amount of solid matter in the gallon, 1211 grains.

Near these springs is a cave in the rock in which the temperature is Hot Cave. considerably over 100° F.; it is undoubtedly connected by a side fissure with that up which the water rises, and owes its temperature to the water. Outside the entrance the rock is covered with dried blood, and the Bedawin informed the writer that those who visited the springs for the purpose of using them as a cure for rheumatism, etc., brought a goat or sheep and sacrificed it to the spirit of the cave, as a propitiatory offering. These springs are called Hammâm Farûn Malûn (the Bath Legend of the Springs. of Pharaoh the accursed) from a Bedawin legend which connects this place with the spot where the Egyptian host with Pharaoh at its head was overthrown and drowned while in pursuit of the Israelites. The hot springs are said to rise up the fissure which was made by the passage of Pharaoh to the nether regions.

Returning to the ridge, it may be stated that it is part of a large anticline which has been broken in the middle by the line of fault which gave rise to the depression of the Gulf of Suez. The hot springs in all probability are produced by the sea-water rising up some of the collateral fissures produced by the line of fracture.

Leaving the hot springs of Hammâm Farûn Malûn, a walk of 7 or Wadi Gharandel. 8 kilometres up the flat sea-beach, (here a flat sandy, and in places loamy expanse between 1 and 2 kilometres wide), brings one to the mouth of Wadi Gharandel. Here it is only 30 or 40 metres wide, and is bounded by steeply inclined cliffs of a gritty limestone. At the time it was visited, a good stream of slightly brackish water was flowing out of the wadi, and losing itself in the sand and gravel of the coast- Running Water, Reeds Trees, etc. plain. Further up, the valley widened and became practically one sheet of water, and recourse had to be had to a path running along the rocks forming the side, which a little higher up became impassable, and the party was driven back into the wadi once more. Its bed was one mass of bulrushes, reeds, and tarfa bushes which rustled in the wind.

As the Suez road was neared, the water gradually began to disappear, and groves of tarfa bushes, gardens, and palm-trees occupied the wadi. Signs were not wanting, however, to show that in winter even this part of the wadi was under water. At the point where the water disappeared from the surface of the wadi, it is joined by an affluent from the east, which drains the low country between it and Wadi Usêt.

All the way up to the point where the Suez road crosses it, the valley is one mass of tarfa and gharqad trees, amongst which one has to pick one's way. Near the road occur the wells which are dug in

the bed of the wadi. These were reported to yield excellent water, but experience did not bear this out. At the time of the visit, in the middle of March, the water had a full, goaty smell, and an unpleasant taste. The Bedawin stated, however, that it was always so in spring and summer when the water was scarce, but that in winter, during the rainy season, it was quite sweet and good. The sides of the valley from its mouth to this spot were composed of a greenish marly, or gypseous clay, which on the north side was capped by a bed of gypsum, but on the south had a covering of conglomerate and boulders. Near the wells the wadi is about 500 metres broad, and is bounded by low cliffs 20 to 30 metres high. Round the wells are several palms, and these continue, together with the tarfa and gharqad bushes, for over 2 kilometres up the wadi, the Suez road leaving it about this point.

Gebel Hoshera.

Passing up the wadi from the place where the Suez road leaves the valley, there are no very well-defined sides to the water-way until Gebel Hoshera is reached. This is a ridge of gypseous marls and gypsum capped by hard coral and beach limestone on the north side of the valley, and difficult to climb on account of the vertical cliffs of the marls and the crumbling nature of the gypsum. From its summit a good view was obtained of the surrounding country. To the west, in the depression up which the Suez road passes, could be seen the green area known as Enqi el Fûl (the Bean field)—so-called because the Bedawin cultivate this area—which receives its water from the surrounding hills and retains it in a basin. Near the cultivated area were a few young palm-trees. On the south of the wadi rises the gypseous ridge of Gebel Gushia from which descends an affluent—Wadi Gushia—entering Gharandel opposite Gebel Hoshera. To the east can be seen the plateau of Gebel Abiad and Hiâla running back into the main table land of Gebel el Tî.

Enqi el Fûl.

Returning to the wadi itself, from Hoshera it presents fairly good going, except for a few places where sand and gravel had accumulated. Along its course clumps of retem bushes occupied the centre, forming little islands round which the "sêls" (torrents) of winter had to pass, and against which they laid their burden of sand and boulders. Higher up gharqad bushes occupied the ground more or less to the exclusion of the retem.

Wadi Abu Qâda.

From Hoshera eastward, the wadi undergoes a change of name and is now known as Wadi Abu Qâda. About 5.5 kilometres beyond the mouth of Wadi Gushia, it receives from the north, Wadi Silfa (so-called because of its wide plain-like character), and about 1 kilometre farther on Wadi Um Retema enters from the south, both of them being short, insignificant watercourses.

About 8 kilometres higher up a more important affluent, Wadi el Abiad, heading in the plateau of that name, enters from the north, the main valley bending round sharply to the east past Gebel el Abiad. This is a tableland breaking up into ridges and isolated peaks near Wadi Abu Qāda, but assuming the characters of a plateau further north, with a slope to the north-west. It receives its name because of its dazzling whiteness, being composed of a white limestone, capped in places by a brown conglomerate. To the wadi it presents steep, vertical sides, up which it is difficult and in many cases impossible to climb.

Beyond these hills where the country opens out somewhat, after passing the end of the ridge of Gebel Krêr which extends from Ethâl to this point, two affluents enter, one on either side, viz: Wadi Nasb from the north, and Wadi Hiâla from the south. Up the latter there is a footpath leading to Wadi Ethâl.

About 4 kilometres higher up, Wadi Um Silfa enters from the north, and the main drainage-line opens out into a wide, open wadi, which just at this point, changes its name to Wadi Wîta. This latter valley was not followed up further, but makes its way in a south-easterly direction through the El Tî plateau.

Leaving the main wadi at Um Silfa, a very bad road over ridges and rugged gullies was followed parallel with Gebel el Abiad and El Tî until the bed of Wadi Baqa (named from Baqa, a bundle of herbs, probably because of the number of plants around and in it) was reached. This may be regarded as the beginning of

(b) THE BEACH PLATEAU, ETC., BETWEEN GHARANDEL AND SUEZ.

At the point where the southern branch of Wadi Baqa leaves the El Tî plateau, the connection between Gebel el Abiad and El Tî ceases, and a plain commences which extends from 29 to 30 kilometres along the foot of the El Tî plateau, being 14 kilometres at its widest from the foot of this table-land to Gebel Kahali (the hill of Kohl). It is covered with downwash in many places, but wherever this has been removed it shows a white chalky floor.

The main Wadi Baqa comes down from El Tî, and is said by the Bedawin to head in that plateau three days' journey inland. There is good water up this valley. After leaving the plateau, it crosses the plain and receives its southern branch near the foot of Gebel el Abiad; between this point and Gebel Sanâfa, a small isolated limestone hill, it receives Wadi Um Rên, and El Abiad from the former plateau, and Wadi Um Adam from Gebel Um Adam, a continuation of the Abiad

plateau. This whole plateau slopes northwards and loses itself under the downwash of the plain.

Just at the end of the Um Adam plateau this wadi is joined by Wadis Melbe and Silfa, and a little further down, Wadi Darba, from the hill of that name, and the combined drainages make up Wadi Wardân (the valley which leads to the spring). In Wadi Melbe there is a well between 1 and 2 kilometres from its junction with Baqa.

Gebel Um  
Adam.

As was previously stated, it is part of the same mass as Gebel el Abiad, and ends in a steep escarpment overlooking Wadi Silfa (the branch running north into Wardân); while it gradually bends round and falls away in a gentle slope towards the heads of the southern draining branches of Silfa and El Abiad.

Wadi Silfa.

This is a valley with a soft sandy or loamy bottom which, near its junction with Baqa, (where it receives plenty of water from the hills on either side) is cultivated by the Bedawin. This wadi heads in a fairly wide plain, with mounds of gypseous marl in it, and receives the water from Gebel Um Adam on the east, and Ziêti on the west. Wadi Amâra also heads here, and passing through the ridge of Hoshera, makes its way across the open country past Gebel Amâra to the sea.

Wadi Amâra.

En Hawâra.

From this point also, a road strikes south-west to En Hawâra, which is on the plain between Wadi Amâra and Gharandel, and about 11 kilometres from either.

Sikkat Amâra.

From Wadi Silfa a path runs over the pass in the gypsum ridge which is a continuation of Hoshera, into the plain through which Wadi Amara passes, and is known as Sikkat Amâra. The country at this point is a mass of gypsum and gypseous marl covered in places by a cap of dark coral or beach limestone, while nearer the sea Wadi Amâra meanders among low mounds of sand and pebbles all the way to the coast.

Following the Suez road northwards, the way led across a low undulating plain dotted at first with a few low hills, and having a low plateau on the east, which, as Wadi Wardân is approached, gradually merges into the above-mentioned plain, sloping south and sending its drainage mostly into Amâra.

Wadi Wardân.

Coming north across the plain which drains into Amâra, there is a gentle rise in the ground over some mounds of gravel mixed with calcareous and gypseous matter, and then a sudden descent into the wide bed of Wadi Wardân. On the south side it is bounded by steep low cliffs of gypsum capped by a conglomerate, while the opposite banks seem to be mainly composed of a gypseous conglomerate. At the point where the wadi was entered it was from 500 to 600 metres

broad, its bed being strewn with boulders, and cut up by numerous small watercourses which meander eastward amongst the bushes of tarfa, etc., which, together with bowwal and sakran, occupy the low mounds between them. After the last few days spent on the arid plain in the vicinity of Amâra, this sudden appearance of verdure was very welcome to the eyes.

Opposite the place where the wadi was entered (a little above the Suez road), it receives from the north Wadi Mas el Dhabba <sup>Wadi Mas el Dhabba.</sup> (? haunts of the hyena) which drains the low, mound-covered plain on that side.

Passing up Wardân, two small valleys were passed, (?) Um Demara, <sup>Gebel Halâfi.</sup> and Sia, which drained the plain to the north. After passing the last wadi the hill of Gebel Halâfi was reached. It consists of alternating beds of gypsum and gypseous marl, much cut up by narrow, deep-sided water-courses, which rendered climbing extremely difficult on account of the rotten crumbly character of these rocks. Forming the top was a hard, crystalline coral rock similar to that on Gebel Ziêti and Hoshera. This hill, together with those just mentioned, forms a ridge of gypseous hills capped by beach limestones, extending from the head of Wadi Gharandel to the foot of Gebel Raha, a distance of 34 kilometres. After leaving this hill the road led across a dull, uninteresting plain covered with mounds of loose gravel and white powdery calcareous or gypseous matter, in the direction of Wadi Tayiba.

At the beginning of Gebel Raha (the flat-topped hill) the escarpment of El Ti ends, becoming fused with the plateau bearing the first name. This is essentially a later plateau which has been evidently laid on against that of El Ti and slopes gently westward, ending in a series of tongue-like extensions into the coast-plain, which has undoubtedly been produced by the denudation of its beds. It consists of a series of sandstones, sandy clays, and some limestone, through which several small valleys have cut narrow steep-sided beds which offer an effectual barrier to the traverse of an otherwise easy table-land. On the way north several small wadis were crossed near their exit on to the plain. These, beginning from the south, are Wadi Abu Hashia, which drains the north side of Gebel el Alhala (a small outlier of the main plateau), Wadi Um Taset, Wadi Ibn el Fili, to the north of which comes Wadi Sadr. This wadi heads in Gebel Sadr or Taset <sup>Wadi Sadr.</sup> Sadr, well inland in Gebel el Ti, the former being the watershed between a feeder of Wadi el Arish, and the valley which bears its name. The "sêl" of the wadi seems to be narrow and bounded by the high white limestone cliffs of Gebel el Raha, and after it leaves the

high limestone plateau, cuts its way through the secondary table-land to the plain. Up this wadi the Bedawin say there is good water, and a road leads up it past Taset Sadr to Nakhl.

Gebel Bisher. Beyond the low plateau of Raha rises the characteristic three-peaked hill of Gebel Bisher, a white limestone mass rising out of El Ti plateau, and a well-known landmark to travellers by land and sea.

Wadi Kahali. Before Wadi el Ahadha was reached the bed of Wadi Kahali (the wadi of the kohl-seller) was crossed. This wadi heads in Gebel el Raha.

*Wadi el Ahadha.*—This wadi, which is so named because horses can be brought thus far from Suez (from “hadhwa,” the point of a horse’s hoof), changes its name higher up its course, to that of Abu Kitâfa. It takes its origin in Gebel Raha, and after leaving the limestone plateau, cuts its way through another low tableland of marls, etc., down to the plain. On its north side and quite close to it is another—Wadi Naqa Gamila—which receives the water from the low plateau of that name.

*Gebel el Raha.*—To the east, the line of view is bounded by the level plateau-like mass of Gebel el Raha which rises up from behind the low plateau forming its foot-hills. This range extends from Wadi Sadr up to a point to the north-east of Suez where it suddenly bends back and becomes lost to view.

Leaving Wadi el Ahadha and going in the direction of the coast, a bare, desolate plain dotted with low mounds and ridges is crossed, through which water-courses, marked by bowwal, rimth, sakran, etc., make their way to the sea. Following the Suez road, the Wadi Dehêsa is crossed, so-called because of the mounds of sand in it. From this wadi northwards the road consisted of a score or so of parallel tracks where the ground was open, dwindling down to two or three where it passed through a narrow cut in a gravel ridge. All the way to Ayun Musa it was an alternation of wide, shallow water-ways separated by low ridges capped by a hard gravel conglomerate, through the gaps in which could be seen the palm trees, etc., which grow round the wells.

Wadi Dehêsa.

*Ayun Musa.*—Just before these wells are reached the ridges disappear, and the road enters a plain which is covered with shell-sand and fragments of various things met with on a beach. To the east of the wells is a low bank of oysters embedded in a mass of loosely cemented grit, while round about the springs the same sort of rock persists. The wells are in fact on a “raised beach area.” They are situated in an indentation in the low plateau which lies around it and practically shuts it off from view from the south.

These springs are situated on a slight rise which falls sharply on its seaward side. It consists of what appears to be gritty material of the beach deposits evidently cemented together by lime deposited from the water. This rise is about three kilometres from the sea-coast and about fifteen from Suez. There are about a dozen springs of various kinds rising up through the rock, some of which are enclosed by a roughly-built wall, while others rise in natural basins evidently of their own formation, resembling a miniature cone and crater, some of which are full of rushes, while others have a clean basin. Some of the springs are utilised for irrigating the large gardens which have been planted, in which vegetables and fruit are grown for sale in Suez. Besides these springs there are a few water-holes which are only used for watering the camels, or washing purposes. Numerous palms and tarfa trees grow luxuriantly in the damp soil on the north side of the springs, forming a very efficient shelter from the wind and sun. Close to the gardens are one or two Arab houses occupied by the gardeners, and there is a more or less well-preserved Levantine house which is built in the form of a café or locanda owned by a Greek, who in company with some of his compatriots, live here and carry on a trade with the Bedawin who work the turquoise mines of Maghara, blasting-powder and other necessities being given in exchange for the rough stones, which are taken to Alexandria and Cairo.

From the wells to the bank of the Suez Canal there are the remains of a carriage road said to have been made by Abbas Pasha, across the boulder-strewn plain which extends down to the sea. This is bounded on the east by a low plateau of clays or marls capped by a bed of hard conglomerate, from which many of the boulders on the plain have been derived. Before reaching the Canal, this plateau bends sharply round in a north-easterly direction, thus giving origin to the plain which lies to the east of the Canal.

To the east of the springs of Ayun Musa, this plateau is cut by Wadi Ayun Musa which comes down from the limestone plateau.

About 4 kilometres to the north-west of the wells are situated the Quarantine buildings of Ayun Musa, to which the passengers and crews of any ships having plague, cholera, or any infectious disease, are sent for varying periods before they are allowed to enter the Suez Canal.

### (c) THE SANDSTONE PLATEAU.

Having described the ground covered by the younger sedimentary formations in detail, it now remains to give an account of the country

covered by the sandstones and limestones of the Nubian series. While in the area just described the general character of the country was that of a plain bounded by ridges of uncoloured beach deposits or gypsum, or a low plateau of monotonous sameness without any features of interest to relieve it, with no trees and scarcely any verdure to refresh the tired eyes of the traveller, as a contrast the district to be described compares very favourably. The many and varied tints of the rocks, ranging from deep red and rich brown through yellow to pure white, furnish a never-ending and ever-varying kaleidoscope of colour effects, especially in the early morning at sunrise, and in the evening at sunset. It is at the latter time that the richest effects are noticeable, when the slanting rays of the westing sun, falling on the pink granite peaks, the jagged edges of the dark, gneissose ridges, and the dark-red rounded masses of sandstone, produce a gorgeous blending of colours shading from delicate rose tints to dark purple, which once seen can never be forgotten. Nor is this all there is to be seen; the wadis which drain this area present some very fine, steep-sided gorges of great beauty, along the bed of which numerous palms, seyal, tarfa, and retem trees flourish luxuriantly, offering very welcome shade from the rays of the noon-day sun; while the floor of the water-courses in the spring months, immediately after the winter rains, is in many places a veritable garden of flowers, and in their higher reaches, near the Debbet el Ramli, beds of lilies clothe the ground in a garment of bluish-white and pink, spangled with their long gladiate leaves.

This plateau may be said to extend from Wadi Ferân, in latitude  $28^{\circ} 48' N.$ , to the head of Wadi Hamr at latitude  $29^{\circ} 10' N.$ , thence running down to the west of the Debbet el Ramli to Wadi Siq and Gebel Dhalâl. From Wadi Ferân to Wadi Shellâl it is bounded on the east by high granite hills, and on the west by the Cretaceous ridge, Gebel Mokateb, Gebel Abu Alaqa, Wadi Budra, Gebel Markhâ, and Sarbût el Gemel, on the south by Wadi Shellâl, and on the north by Debbet el Ramli and Gebel el Ti.

At this point, it is not proposed to describe any of the wadis except those actually draining the area, those outside or only on the borders will be dealt with in the chapter on the igneous ranges.

Wadi Mokateb. Commencing then from the southern boundary on Wadi Ferân the first wadi to be noticed is Mokateb (the written wadi so called from the number of inscriptions found there). Leaving the above-mentioned valley, the road winds up through a rough boulder-strewn water-course draining south, and broken by low ledges of sandstone over which laden camels scramble with difficulty. After a walk of 3·5 kilometres

or thereabouts, the watershed is crossed and the true Wadi Mokateb is entered, which is a broad valley running down to the north between low walls of red sandstone, on which are carved the numerous inscriptions which give it its name. At its head it is practically an open plain with isolated mounds of sandstone; but later on these close up and form walls from 6 to 12 metres high, rising to 20 or 30 metres near its mouth. Near its origin it receives the Wadi Kateb from the south-west, and various other small feeders from the hills on either side on its way down to join Wadi Sidri. (For an account of the inscriptions see supplement to Part I, Ordnance Survey of the Peninsula of Sinai). In the bed of the wadi a few seyal trees are growing, and rimth is the main plant of the herbaceous variety.

At the point where it enters Wadi Sidri, the latter expands into a wide, shallow water-course—Sêh Sidri—in which are many seyal trees. From thence the wadi bends westward and running in a broad course between the terraced sandstone hills on either side, passes out through a steep-walled gorge at Abu Alaqa to the sea. The country around the Wadi Mokateb is practically a basin of low sandstone hills sloping down to Sêh Sidri, and overlooked by the commanding hill of Gebel Merzeqa on the east, and Abu Alaqa on the west; it has been faulted down to the west, as has the whole area up to Wadi Shellâl.

*Wadi Qena.*—About 7 kilometres down from the entrance of the Wadi Mokateb, Wadi Sidri receives from the north-east, Wadi Qena, which at its mouth is about 100 metres wide, and is enclosed by nearly vertical cliffs of soft sandstone between 70 and 90 metres high. About 1 kilometre from its mouth it receives the small feeder Wadi Qenaia in which occur the workings for turquoise in Gebel Maghara. The larger—Wadi Qena—bears north-east and immediately opens out into a wide, sandy plain containing many granite boulders and numerous well-grown seyal trees, the expanse ending against the granite range about 4 kilometres distant. In this range the wadi takes its origin, issuing from it by a narrow gorge.

Near the foot of the granite range is a well containing a perennial supply of good water, and said by the Bedawin to have been dug by Major Macdonald who worked the turquoise mines for some years. About half a kilometre above the entrance of Wadi Qenaia are the ruins of Major Macdonald's house, with the remains of what may have been a garden close by.

*Wadi Qenaia.*—This wadi runs for about 1 kilometre between steep-sided cliffs, then suddenly narrowing into a small gully breaks up into two, one branch—the shorter—bends north-west and after crossing a piece of low country ends in a precipice in a hill on the west; the other main branch holds a northerly course among low cliffs for 4 kilometres and ends at the foot of the granite range.

*Gebel Maghara.*—This is a more or less rectangular hill capped by a basalt flow. In it occur the workings for the turquoise. The following are the names of some of the workings in this and the neighbouring hills.

1. *Zafarana*: This occurs in the small triangle of sandstone between Wadis Sidri and Qena, and faces the former.

2. *Hagaga*: This is the most southerly one in Wadi Qenaia; of these there are four at present worked; the first is worked only on the face of the rock; the second has a short gallery which ends in a deep well-like shaft, as does also the third; while the fourth has a large working 12 to 15 metres high from which a short gallery has been commenced.

3. *Yahudia*, is said to yield the best stones and is worked along a short gallery.

4. *El Rodd*, is worked on the face of the cliff. Besides these there were two evidently ancient Egyptian workings which for superstitious reasons the Bedawin avoided.

These workings occur in the cliff from 40 to 60 metres above the valley, and are found over a distance of 200 to 300 metres.

Facing this is a small, flat-topped, conical hill lying in the angle between Qenaia and Qena on the top of which are the ruined houses of the miners and their guards. (For further description of this place with the hieroglyphics found there, see Ordnance Survey, Peninsula of Sinai, Part I, pages 167-180).

Leaving Wadi Qena, and following that of Sidri, the road winds between vertical sandstone cliffs for about a kilometre, when suddenly a boss of granite appears on the left, rising up into sheer precipices and pinnacles, and lending grandeur to the scene. This has evidently acted as an obstruction to the water, as it runs parallel to its length and has made its way round the end of it, bending sharply back to its original direction and holding on its way past the mouth of Wadi Budra to the sea.

Opposite the mouth of Wadi Qena in Wadi Sidri, there is a sheikh's tomb at which the Bedawin pay their devotions.





NAGB BUDRA



LOWER PART OF WADI FERAN.

Turning to the right out of Sidri, Wadi Budra is entered about 3 kilometres below Maghara. This is a fairly wide valley which rises rapidly to the north, and soon divides into a number of branches which lose themselves among the steeply-inclined ridges of sandstone. On the west it is bounded by the steeply-tilted Cretaceous marls, and on the east by the edge of the sandstone plateau. The bed of the wadi is clothed with bushes of rimth and shia, while seyal trees occur here and there. After the wadi breaks up near its head, the path wanders about amongst low hills of vari-coloured sandstone and shale, ranging from yellow, red, purple, to blue, until after about 3 kilometres it reaches the pass known as the Naqb Budra. This is a sudden drop into the basin of Wadi Shellâl, and is negotiated by a winding path which crosses and recrosses the side of the pass; here and there the path is strengthened by a loose wall; while at other places the camels have to slip and sprawl over rounded knobs of sandstone.

On the left is Gebel Naqb Budra which presents a piece of fantastic sculpturing in the sandstone which forms its base, above which succeed successive terraces of limestone and marl to its summit, from which a fine view of the surrounding country is obtained. Looking eastward the sandstone is seen to consist of a massive plateau cut up by narrow, steep-sided wadis, and having patches of basalt dotted about on the higher summits. Towards Wadi Shellâl it slopes down quickly and has undoubtedly been let down by a fault against the granite on the north of the valley. After descending the Naqb Budra, the road leaves the wadi of that name, and crossing the heads of one or two small water-courses descends rapidly towards Wadi Shellâl. The ground passed over consists of sandy shales and sandstones of many colours, and is covered with a ferruginous slag-like gravel derived from the sandstones of the plateau. The road on entering the Wadi Shellâl runs for about 2 kilometres in a direction west of north until it reaches Wadi Baba, from whence it turns west into Sêh Baba and El Markhâ.

Leaving the road at the junction of the two above-mentioned valleys it is now necessary to give a short account of Wadi Shellâl as far as it is known.

From its junction with Baba, as stated above, its "sêl" lies along a west-of-north line, having a width of 100 metres or so, and a fairly smooth bed covered with soft sand which makes heavy going. On the east, it is bounded by hills of dark green gneiss capped by red sandstone and brown limestone, which show a terraced appearance due to step-faults; while its western side is formed of steeply-tilted beds of Cretaceous marls and Nubian sandstone. At the point where the

camel path to Naqb Budra leaves it, it takes a sharp bend eastwards and 2 kilometres higher up receives Wadi Budra, and half a kilometre further on Wadi Abu Aqila from the south. Up to this point both sides are formed of the red sandstone and limestone of Carboniferous age, which between the entrance of these two wadis form a cataract about 6 metres high, owing to the limestone crossing its bed. (It is probably from this that the wadi receives its name "Shellâl" meaning cataract.) Passage to the upper part of this wadi is obtained by a rough camelroad winding up its north side. Above the cataract the valley opens out into a wide bed in which the Bedawin encamp in the early spring with their flocks, water being reported higher up at a place marked by a few palms. Above the cataract the wadi was not explored; but from the surrounding hills it was seen to enter the granite and gneiss hills by a narrow gorge, and its head was not very far above that point.

Inscriptions. On the sandstone and limestone immediately below the cataract several Sinaitic inscriptions were noticed.

Wadi Baba. Returning to the mouth of Shellâl it is now necessary to go up the Wadi Baba in order to see the country from the best stand-point. At its mouth this valley is about 200 metres wide owing to its junction with the Wadi Samra, and also to the sudden arrest and replacement of the igneous and metamorphic rocks by limestone and marl which weather easily.

Just by the mouth of Wadi Samra is a small hill of red granite, which makes a striking contrast with the dark-green and gray gneissose rocks forming the hills at this point with their caps of red sandstone. They rise up sharply from the plain, towering peak over peak in all their rugged grandeur. Immediately on entering the hills the valley assumes a very tortuous course, bending and twisting in a most remarkable way through as fine a gorge as any in the peninsula. In places the bed of the wadi is no wider than a path, a laden camel having very little room to spare on either side; while again it opens out a little only to close in once more. Its floor is strewn with huge boulders of granite; while numerous small ledges occur over which the camels have to clamber. On either side the granite hills rise in precipitous cliffs of over 300 metres in height, while they tower away peak above peak for over 300 metres more. Down the sides of these hills, during a rainstorm, pour numerous small tributary streams, some of them falling over cataracts 100 metres high. The scenery here is of the grandest and most savage description, the hills closing in so that the wadi is in perpetual shadow, while into some of the sharp bends the sun never penetrates.

In nearly every little side valley there are rock-basins containing water, but inaccessible, except to men who can climb the slippery, polished rocks in the way. Palms, too, are present here and there where the water occurs near the mouth of the tributary wadi.

For 5 or 6 kilometres the valley continues its tortuous course, and then the hills, which have been gradually becoming lower, open out, and little by little the gneiss and granite become covered up by sandstone, and disappear below ground. This is an exceedingly dangerous place to be caught in during a rainstorm, as the wadi has an extensive collecting ground, and in the confined space of its lower reach the water must rise at least 20 metres, judging by the appearance of the rocks on either side.

From the point where the wadi began to open out, running water was met with which occasionally disappeared in the sand only to reappear again at another point. Numerous palms and tarfa trees grow luxuriantly where this water flows. The character of the water is poor, being brackish and undrinkable. For 5·5 kilometres or thereabouts, this water is met with and the palms seem to accompany it, but a little above the mouth of Wadi Hamât they disappear.

Running  
water, Palms,  
etc., in Wadi  
Baba.

About half a kilometre above the entrance of Wadi Hamât, is that of Wadi Khallîq, a small wadi draining the low hills to the north. In it occur one or two "maghara" or mines, in which manganese and iron ores occur about a kilometre from the mouth. Opposite its junction with Wadi Baba there is an Arab burying ground.

Mines.

About 2·5 kilometres higher up the Wadi Baba opens into a wide sêh, or plain, formed by the junction of four drainages, viz., the two branches of Baba from the north-west and north, the latter receiving Wadi Bêda from the Debbet El Ramli, and Wadi Nasb and Suwiq. From this point, looking westward, the country is seen to be a plateau sloping towards the east and north from the high ridge forming the boundary of El Markhâ and the granite and gneissose range away to the south which forms the watershed between the feeders of Wadi Sidri and Baba. It is essentially a sandstone country in appearance, showing the flat-topped hills separated by the narrow, vertical-sided gullies so common in such an area.

This is one of the most important feeders of Wadi Baba. At its mouth it is a shallow water-course about 100 metres wide, bounded on the west by cliffs of sandstone only a few metres high, while on the east the same rock rises 60 to 90 metres above the floor. The explanation of this is that the country has been let down by a fault to the west, along line whose the valley has formed. About 2·5 kilo-

Wadi Nasb.

metres from its mouth, gneiss appears at the foot of the eastern cliff and continues up to its head. Along the bed of the wadi numerous well-grown seyal trees occur, which were probably grown in much greater numbers by the ancient miners for the supply of the charcoal for the smelting of the ore found in the vicinity.

About 5 kilometres from its mouth there are the ruins of a village with large heaps of copper slag. Close by are one or two gardens in which are a few palm and sidr trees, and two or three springs from which the gardens and a little of the surrounding land are irrigated by means of shadufs. Near by are several caves or galleries, probably made in search of ore though some may have been occupied as dwellings.

From the ruined village a path strikes off across the ridge towards Serabit el Khâdim. Several other paths start off from this point to the old workings which occur all over the plateau.

Wadi Suwiq  
and its  
tributaries.

Leaving the mouth of Wadi Nasb, the path leads up Wadi Suwiq towards Serabit el Khâdim. On the left it receives the small affluent Wadi Ikfa which heads on the edge of Debbet el Ramli, and on the right, 1.5 kilometres from its mouth, Wadi Lahiân, a long, broad, steep-sided water course which heads about 7 kilometres to the south. Between this and the next important tributary on this side—Wadi Bala—are two unimportant feeders, Wadis Zebêr and Nimla.

Wadi Bala.

Wadi Bala which enters from the south about 4 kilometres above Lahiân, is a fine broad valley cut in gneiss with the sandstone capping it on either side. Like the latter it has a plentiful growth of seyal trees in it.

Wadi Habûs.

From the left entering opposite Wadi Nimla comes the important affluent Wadi Habûs which drains a large piece of Debbet el Ramli, its continuation being the Wadi Garf. About a kilometre further on Wadi

Wadi Merâq.

Merâq enters from the east from its source in the sandstone hills bordering Debbet el Ramli. This valley is so called because of the broad, meadow-like expanse near its mouth. Round it a good deal of blown sand has been accumulated and consolidated, and now yields a certain amount of pasture for the flocks of the Bedawin who have an encampment there. Near here was the home of one of the sub-sheikhs of the Towara, Modakhal Suliman.

Wadi Suwiq ends in a Naqb from which it descends steeply at first, flowing primarily in a north-westerly direction and then bending round to the west. It is bounded by the vertical cliffs of the Carboniferous sandstone, and winds about a good deal on its way to join Wadi Baba.

In a small wadi west of Habûs there is a deep well dug in its bed and properly pitched, which yields a fair supply of brackish water. The name of the wadi is Melha.

Having put down the camp for a day at the mouth of Wadi Serabît <sup>Serabît</sup> el Khâdim, an ascent was made to see the ruined temple which is on the top of the plateau. Leaving the camels, a path was followed up the wadi for a little, and then it began to wind slowly up the hill ledge by ledge until the plateau was reached. This temple has been fully described in the "Ordnance Survey of Sinai," Chapter VII, pp. 192-3. Here there are some old workings for turquoise which are said to be exhausted, any stones now found being worthless.

Climbing the hill behind the plateau on which the ruined temple stands <sup>Gebel Serabît</sup> el Khâdim, a good view of the surrounding country was got for tens of kilometres round. The hill itself is roughly rectangular in outline with its longer axis lying north-west and south-east. The sides are very steep and difficult of ascent, this being largely due to its having a cap of basalt which, acting as a protective covering, yet allows of the weathering of its sides. To this is to be attributed its greater height above its immediate neighbours. Falling off in a south-westerly direction is a tongue which runs up to the base of Gebel Tatar el Dahami, a granite mass whose summit is composed of a col of sandstone; while to the south the gneiss country is seen spreading out on either side of Wadi Um Agraf. To the east the course of Wadi Siq is seen, as it meanders its way down from El Tî, the whole of which escarpment is visible as a wall extending from Gebel Dhalâl to the head of Wadi Hamr, with the plain of El Ramli lying at its foot. To the west, in the immediate foreground, stand up the two well-defined peaks of Gebel Um Riglên (so called because of their resemblance to two legs); while the sloping sandstone plateau is seen rising up to the heights of Gebel Baba, and sinking to earth to the north beneath the sand of the Debbet el Ramli, the wadis appearing like open drains at intervals in it.

From the mouth of Wadi Serabît el Khâdim the path leads over the <sup>Naqb Suwiq.</sup> Naqb Suwiq, (which is impassable for laden camels, and difficult even for heggin) into Wadi Khamîla. This latter wadi will be described along with Wadi Um Agraf of which it is a tributary.

There now remains to be described the piece of sandstone lying between Wadi Siq and Gebel Dhalâl. Between these two places there is a difficult path over the rough sandstone ledges which leads to the head of Wadi el Akhdar. In this area the combined action of wind and sand are well seen. Here also is met with for the first time a pure white sandstone which dazzles the eyes, and is worn into most fantastic

shapes round the foot of Dhallâl. Looking from the west at this hill and its continuation of Gebel el Ti, there is a series of terraces and buttresses alternating up to the base of the limestone cliff which are wonderful in their variety. The contrast, too, between the white and dark-red sandstone is very striking, and the way that the white caps the other gives the impression, from a distance, of banks of snow resting on a brown floor. The brown variety runs out in an irregular manner on to the igneous rock behind, this being due to its unequal removal by the weathering agents.

Much sand has accumulated at the head of Wadi el Akhdar and when this place was visited about the end of February it was covered in many places by beds of lilies.

### 3.—THE MAIN MOUNTAIN MASS.

Having now finished the whole of the sedimentary area, it only remains to describe the large mass of igneous and metamorphic hills which extends from a little to the north of Wadi Um Agraf and Wadi Sidri to the neck of Ras Mohammed. In the introduction it was proposed to divide this district into two, viz. (*a*), that north of Wadi Hebrân, Solâf, and Gebel Gharbi, and (*b*), the district to the south of that line.

This division will still stand but instead of describing each district as a whole it will be taken wadi by wadi and the country seen on each side with the tributaries flowing into it will be described as they are passed, while a general summary of the salient features of the district will be given at the end.

#### *a*) COUNTRY NORTH OF WADI HEBRAN.

*Wadi Siq*.—Commencing from the north this is the first main drainage of the district. Rising in the plateau of El Ti, it flows west for 5 kilometres along the foot of that escarpment and for 5 kilometres more in a wide course through an open sandstone plain, at this point receiving its first affluent, Wadi Shêqer, (so called from its brownish clay colour, "shêqra," clay) from the low hills on its left bank.

*Wadi Shêqer*.—This wadi, where it enters Wadi Siq, is very wide, the country being practically a plain. It takes its origin at Naqb

Shêqer, a difficult pass which takes the best part of an hour to walk over on foot, and for camels considerably longer, it being only practicable for heggin. Its whole course is in gray granite with outliers of sandstone dotted about here and there upon it, its total length being 12 kilometres. About 3.5 kilometres from its mouth it receives from the east an important feeder, Wadi Berq, which rises in the sandstone hills at the foot of Gebel Dhalâl. For three kilometres it runs through the plain in which Siq is, and then enters the sandstone; in 2.5 kilometres more it changes its name to that of Gharbi, a small branch from the north, taking that of Berq, and 4 kilometres further on it heads in the foot-hills of the above-named hill. For practically the whole of its course it runs more or less parallel with that of Siq. Water is plentiful in Shêqer and Gharbi. Wadi Berq.  
Wadi Gharbi.

Returning to the mouth of Shêqer and resuming the course of Siq, about two kilometres further down the mouth of Wadi Um Bassal is passed, a short valley which drains a small open plain into which Wadi Enqaib enters.

The small plain above-mentioned is a curious example of the kind of watershed met with in this high plateau; it differs thus from those lower down where the parting is marked by some very abrupt line of division in the shape of a rugged ridge or dyke.

From Wadi Um Bassal there is a path over a low pass into Wadi Entish (named from a plant natesh or latsh which camels eat) which enters Siq six kilometres below Um Bassal. This wadi is bounded by steep sides of gneiss which shut out all view from the north as by a wall; but the bed makes excellent going, and supports numerous plants which yield food for the camels. Wadi Entish.

About a kilometre below Entish, Wadi Siq receives an important tributary, Wadi Monia. This wadi transgresses considerably on the basin of Wadi el Akhdar; it rises close to the head of Wadi Esh, and drains the east side of the granite mass of which Gebel Hamra is the highest point, and the flat-topped metamorphic plateau extending from it to Wadi Siq. At its origin it takes the name of Wadi Bum, and flowing north-east for 5 kilometres until on a level with Naqb Shêqer, bends round to the south-west towards Siq, then takes the name of Monia, and has a total length of 23 kilometres. Wadi Monia.  
Wadi Bum.

From this point onward, Wadi Siq has a firm sandy bottom; it has the open plain of El Ramli on its right for about 5 kilometres; after which it enters the sandstone plateau with gray granite at its base, having almost vertical cliffs on either side, while its left is furrowed by narrow, steep-sided gullies which drain the plateau to the south. About

10 kilometres from Entish the mouth of Wadi Tayiba is reached ; here Wadi Siq bends sharply north about a kilometre and then turns once more eastward. Opposite the mouth of Tayiba there is a sudden widening of the valley caused by the junction at this point of Wadis Sheikh Ahmed and Maraikh, the former being named from a Bedawi saint whose tomb is there, while the latter is named from Markh, plural Maraikh. Both of these affluents are short, wide wadis, down the former of which comes the path from Serabit el Khâdim to the Dêr at Gebel Musa, while the latter drains the plain of El Ramli. In this small plain a little piece of the loamy sand has been enclosed and is cultivated by the Bedawin.

Wadi Tayiba.

Wadi Tayiba at its mouth is a fairly broad valley with a somewhat rocky bottom, covered with a fair amount of vegetation and having some very well-grown seyal trees in it. Two and a half kilometres up it bifurcates, the branch bearing its name running off to the south where it heads near Gebel Tayiba, a distance of 7 kilometres from the fork, and near which is the origin of Wadi Nisrin. The other branch,

Wadi Barraq.

Wadi Barraq or Barq (so called because a Bedawin encampment was here destroyed by lightning) bends off to the south-east, and is a fairly wide valley, about 80 metres broad, and has a very rough stony bottom. Several well-grown seyal trees are found here. About three kilometres from its mouth the last of the sandstone is seen ; and immediately beyond this enters, the tributary, Wadi Ibn Sakkar, up which good water is said to be found. From this point, the sides are composed of metamorphic rocks in which many dykes and veins are seen, and as the head of the wadi is neared the road becomes extremely rough and stony, finally ending in a rough path over a small ridge until the plateau is gained. Here there were some nawâmis, (i.e. ruins of houses, etc., of the ancient inhabitants). The total length of the wadi is 10 kilometres. Up this valley goes the path to Gebel Musa.

Returning to Wadi Siq, at the junction with Wadi Sheikh Ahmed and Maraikh, the former widens out into a narrow plain called Sêh Barq. On the left bank is a high cliff of quartz-felsite, with sheer sides facing the wadi, which forms the edge of the plateau of Fersh Abu Alaqa from which a good view of the surrounding country can be obtained. Looking north, the great plain of El Ramli stretches away to the bounding wall of El Tî; while to the east and south, a flat-topped, sloping plateau is seen rising with a gentle inclination from the base of El Tî towards the high ground in the neighbourhood of Wadi Fêran and Serbâl, dotted with a few outliers of sandstone,

but beyond these having no salient features to vary the monotony of an otherwise featureless tableland, and recalling very vividly to the mind the description of a "plain of marine erosion" which this has undoubtedly been. It is nevertheless divided into areas named after the wadi draining them, as for instance Fersh Sidri, Fersh Nisrin, etc. To the west and north-west can be seen the peaks of the gneiss hills overlooking Wadi Mokateb, the granite hill of Gebel Merzeqa, and its extension to the Gebel Tâtar el Dahami, while sweeping round towards Serabit el Khâdim is the edge of the sandstone plateau resting on the gneiss which forms the whole of the country to the west. Immediately below can be seen the small triangular patch which is bounded by Siq, Wadi Sheikh Ahmed, and Khamila, the latter of which is next to be described.

This valley, so named because of its sandy bottom, takes its origin <sup>Wadi Khamila</sup> near Naqb Suwiq, and after flowing south-east for 8.5 kilometres, bends sharply round and flows to the south-west for other three kilometres, when it enters Wadi Um Agraf, (the continuation of Siq); the latter name is apparently only given to the upper part of the main wadi. Khamila, at the point where it changes its course, receives another short branch from the south-east from Debêbat Sheikh Ahmed.

About four kilometres below the entrance of Khamila the Wadi Um <sup>Wadi Um Agraf.</sup> Agraf itself enters Wadi Siq from the north-east. It heads near the base of Gebel Serabit el-Khâdim, and flows south-east in a steep-sided bed in gneiss capped by sandstone, finally turning to the south-west and entering the main valley. From about this point it becomes clothed with a carpet of many-coloured flowers in the spring time, its sandy and loamy bed being suited to the growth of these plants. Seyals grow in abundance, too, and altogether this wadi is one of the pleasantest of those traversed. The walking is excellent, good firm footing being always to be had, while the rough patches of boulders can always be avoided. This character is maintained the whole of the way to the entrance to Sêh Sidri.

Below the entrance of Wadi Um Agraf, the main wadi assumes a very tortuous course, winding about like a huge snake, and receiving only the unimportant affluent of Wadi Biyut (the valley of houses) from the gneiss hills on the right, until it reaches the entrance of Wadi Sidri. On either side the country has lost its plateau-like character; it is more broken up and diversified by ridges and peaks, especially on the right; but on the left this character only holds in the immediate neighbourhood, its southern boundary being Wadi Um Fêh which

separates the broken ground of Gebel Um Fêh from Fersh Sidri, a part of the main plateau described above.

**Wadi Sidri.** After winding about for about 7 or 8 kilometres Wadi Um Agraf enters Wadi Sidri which comes from the south-east. The latter is a fine broad wadi studded with numerous seyal trees. It rises in Fersh Sidri, flows west of north for 3 or 4 kilometres, then bends sharply to the west at the point where it receives Um Fêh and continues this course with but little deviation till it leaves the hills. A little further on, it receives the small tributary Wadi Dâma from the right. From this point the wadi passes through granite, the culminating peak of which is Gebel Marzeqa, a fine commanding height overlooking Sêh Sidri and Mokateb.

**Wadi Neba.** On its south side enters Wadi Neba, a small drainage in which water is said to occur. At its mouth were a few stone huts which the guides said were used for storing corn when a consignment was received from Suez. This the Bedawin were busy doing when the writer passed this place.

**Wadi Ferân.** Leaving this valley, the next to be described in detail is Wadi Ferân. Starting from the point where the small branch of Mokateb enters it, and going up the wadi for about 2·5 kilometres, the mouth of Wadi Nisrîn (valley of the eagles), the first important feeder from the north side is reached. This valley takes its rise away up in the plateau near the head of Wadi Tayiba in Gebel Tayiba, and flowing west receives the drainage from Fersh Nisrîn, after which it sweeps round the base of a red granite hill, and passing along amongst the low mounds of gray granite which occupy the space between that hill and those of gneiss overlooking Wadi Mokateb, passes out in a south-westerly direction into Wadi Ferân. At its mouth some stone circles occur. From the mouth of Wadi Nisrîn, Wadi Ferân goes up in long, open reaches 300 to 500 metres wide in places, the floor being made of clean granite and gneiss gravel well packed and easy to walk on, while rimth and shia occupy the sandier parts, and well-grown seyal with occasional tarfa trees are studded all over its course.

**Wadi Nidia.** About three kilometres above the mouth of Wadi Nisrîn the sedimentary rocks cease, their boundary being marked practically by the course of Wadi Nidia (moist valley), which enters here from the south from its source in the limestone hills. The contrast between the metamorphic rocks and the sandstone which is here laid against them is very striking; the former have a dark-green, sombre colour, while the latter has a rich, warm brown. From this point the road lies between gneissose

rocks, those especially on the north side rising steeply in sharp, jagged ridges which often culminate in a conical-shaped crest, and in many cases offer sheer precipices to the daring climber which baffle his boldest attempts. On the south side the same character is seen, but on a much smaller scale. The hills are here veined and dyked in a wonderful manner by various kinds of rock, the principal of which are dolerite and quartz-felsite. It is higher up, however, beyond the oasis that this phenomenon is seen at its best. There the dark-green, gneissose ridges are crossed by hundreds of dykes and veins, the red felsite predominating, and only separated from each other by one metre or less, while they cross and interlace in the most wonderful manner. In other places, dolerite and felsite alternate, the warm, dark-brown weathering of the former contrasting well with the brick-red of the latter. In many cases the ridging of the gneissose hills is due to the presence of a hard dyke. On the south side of Ferân in some of the small wadis such as El Tarr, some beautiful examples of folding are seen in the gneisses, the folds being marked by alternate layers of black mica and white quartz and felspar.

About 2 kilometres above the mouth of Wadi Nidia there enters from the north-east the important tributary of Wadi el Rummana (the valley of the pomegranate) which will now be described. This is a fine, broad valley studded with seyal trees, having its bed made up of clean, well-packed granite and gneiss gravel which affords good footing. About a kilometre from its mouth, there enters from the north the Wadi Darqîd which heads in a red granite boss, from which a good view of the district is obtained. Standing on this hill, looking east, the Fersh Nisrîn with the wadi is well seen on the north side, a splendid bird's-eye view being obtained of its course; while away to the east, over the ridges of gneissose, gray granite, could be seen the head of Wadi Aqr and its junction with Wadi Lebwa; to the south-east rise the plateau of Yena, Gebel el Banât and Gebel Goze, the two latter being seen for a long distance from every side, and easily recognized by their dark-red colour and peculiar rounded summits; and still more to the south rise the red peaks of Serbâl in all their rugged grandeur, set as it were on a base of dark-green gneiss.

Across the hills at the foot of this ridge, red dykes run in a north-easterly direction, and can be seen extending for kilometres away. From this hill it is very difficult to find a way down, all the water-courses ending in precipices; while the sides are very treacherous and rotten. In the wadis, water occurs here and there in holes at the foot of polished water-falls which have to be negotiated in a sitting posture; while

farther down one has to thread one's way amongst huge boulders, thousands of kilos in weight. In the sand amongst these boulders, hamad, a succulent plant of the genus *Rumex*, grows in great abundance, and is collected by the Bedawin for their camels who eat it with every sign of relish. Asphodels also grow in abundance in the wadis.

About 2·5 kilometres from the mouth of Wadi Darqîd, the valley bends round to the north-east, receiving a drainage from the vicinity of Gebel el Banat, and zigzagging about, receives several small tributaries from the north, among the most important of which are Wadi Hallâl from Gebel Hallâl, Wadi Ganûs which drains the high ground to the north, and Wadi Ekba from Gebel Ekba, a small boss of syenite which presents a precipice of over 100 metres in height. Further up about 3·5 kilometres above the bend to the north, the wadi makes a sigmoid twist and shortly afterwards changes its name to that of Rahaba (the expansive valley). All the way up the valley the hills preserve the same character, viz, that of a plateau much cut up by dykes, and short, steep gullies which run rapidly to the top of the table-land. From the sigmoid flexure, the wadi continues with very little deviation in a north-of-east direction until it reaches its junction with Wadi Aqr, (Akhdar of the Ordnance Survey). Wadi Rahaba keeps its eastward course and opens out into a plain near its head, the ground being covered with heaps of granite debris, and low mounds of granite. From this plain there is a rugged pass through a narrow granite ridge, consisting of a series of steps, up which the camels have to clamber very carefully. This pass is impracticable for baggage camels.

Wadi Rahaba.

Wadi Aqr.

Returning to the Wadi Aqr, its course is for the first three kilometres, slightly west of north, after which it bends sharply round almost due east, turning again sharply north to its head near that of Wadi Barraq. Round its course the country is open and the hills are low, at its head being only a few metres high. As it descends rapidly they soon increase in height, but there is a sameness about them which amounts to monotony.

Wadi Lebwa.

At the head of Wadi Aqr, the country to the south-east, owing to the denudation of the red granite, opens out into a sandy plain five kilometres wide, clothed with retem, shia, and other desert plants. Here again the same phenomenon was seen as was noticed in Khamîla, viz, the flowing of two lateral valleys to meet each other. From the north-east comes Um Retema draining the low hills in that direction; while Wadi Lebwa receives Wadis Dhenêb and Hanêk and one or two more small tributaries.

Um Retema.

Wadi Lebwa can scarcely be called a wadi as it is merely a drainage

line across this plain; it begins near the head of Wadi Barra (which runs to El Akhdar), where the watershed is scarcely noticeable.

Wadi Rahaba and Rummana seems to be a very important valley judging by the number of Bedawin encampments seen in it, and the number of sheep, goats and camels grazing in it. The valley itself yields good fodder; and as there is not much difficulty in getting on to the plateau the supply of forage is practically inexhaustible. The water supply is good, water being found in nearly every little valley which comes down from the plateau; and the presence of numerous well-grown seyal trees all down the wadi, shows that water is present in its sandy bed not far below the surface. That it is visited by heavy storms is evidenced by the deep ruts cut in its bed, and also by the big mounds of boulders which are heaped up here and there, making the upper reaches of the wadi rather rough going.

Returning to the mouth of Wadi Rummana, and going up Ferân for Wadi Ferân. about two kilometres, the mouth of Wadi Bashîh, a considerable tributary Wadi Bashîh. is reached which, heading in the gneiss close to the valley of El Tarr, runs north for 6 kilometres and empties itself into the main valley.

As Ferân is ascended, the mountains forming its sides become higher and wilder, and gradually close in, the bed of the wadi becoming much narrower. Strong evidence of the resistless force of the torrents is seen in the huge masses of detritus piled up in the side valleys and at their mouths, and which have been cut through in a wonderful manner, leaving vertical sides 20 to 30 metres high.

In Wadi el Tarr these are seen at their best, vertical mounds of Wadi el Tarr. limestone pebbles standing on the sides as high as 30 metres above the valley. In many of these side wadis may be found a Bedawi and his family with a goodly flock of sheep and goats, the latter predominating and numbering as many as 50. Up this valley one catches glimpses of the limestone plateau behind, the last glimpse being got as the mouth of Wadi el Gabari is passed.

Opposite the entrance of Wadi el Tarr, from the left bank, is the mouth Wadi Qosêr. of Wadi Qosêr, (the short valley) a wide, rough-bottomed valley in which many well-grown seyals are seen among the granite boulders. Up it a glimpse of Gebel el Banât is first observed; but it is not until Wadi Gebel el Banât. Um Fus is reached that a full view of this striking hill is obtained. To the west, it presents an almost precipitous front, impossible of ascent; while it towers up in a high conical summit far above the surrounding hills. Its rich colouring, especially when bathed in the rays of the setting sun, is wonderful, and not soon forgotten, completely eclipsing anything seen in any other part of the peninsula. It receives its name

from a legend current among the Bedawin, that two girls who had been promised in marriage to two men whom they did not like, fled there, and when pursued, rather than marry against their inclination, threw themselves over the precipice mentioned above and were dashed to pieces.

Wadi Um Fus.

This is a considerable tributary which receives all the drainage from Gebel el Banât, as well as some from the plateau of Yena which lies to the east. From the mouth of this wadi, the hills on either side are so close and their sides so steep that they cut off all view of the neighbouring range of Serbâl.

Gebel Serbal  
General  
Description.

The main topographical features of Gebel Serbâl are described in the following letter of Captain H. S. Palmer,\* R.E.:

“Feiran February 2nd, 1869.—Our camp here is pleasantly situated, at the junction of Wadi 'Aleyat and Wadi Feiran, and close to the oasis of Feiran which terminates just at this point. . . .Jebel Serbal is about four miles from the camp. In massive ruggedness and in boldness of feature and outline this mountain certainly presents an aspect unequalled by any other in the peninsula, and, though not absolutely the highest, it has a greater command over the surrounding country than any we have so far seen. Unfortunately there is hardly a single point in the valleys near its base (on this side at all events) which affords a really comprehensive view of the mountain. It is only by ascending some of the neighbouring hills that the whole range of its magnificent peaks can be seen at once, and there is no plain anywhere in the vicinity suitable to the assembling of a large concourse of people in sight of any one portion. Two unimportant valleys, Wadi 'Aleyat and Wadi 'Ajeleh, each from three to four miles in length, rise from Feiran to the actual base of Serbal, and furnish the roughest examples we have yet experienced of the very rough walking in the peninsula. Each—and especially Wadi 'Ajeleh, the western and narrower valley—is a wilderness of boulders and torrent-beds and high banks of alluvial deposit bearing the marks of many a *seil*. From points in these two valleys, and from a few spots also in Wadi Feiran, partial views of Serbal may be had, but from Wadi 'Ajeleh the highest peak is never seen. The space between the two, which I think has been described as a ‘plain,’ is a chaos of rugged mountains, rising to as many as 2,400 feet above Wadi Feiran, and concerning which our boots and knees could tell a very different tale.

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\* “Ordnance Survey, Peninsula of Sinai,” Vol. I., Chap. III., pp. 89-94.

“ There is, however, a third valley, Wadi er Rimm, not mentioned <sup>Wadi er Rimm.</sup> in my letter, which receives the drainage of the north-eastern slopes of Serbal, and flows eastward to meet Wadi Feiran at a point about seven miles above Paran. This valley, in its main characteristics, closely resembles Wadi 'Aleyat and Wadi 'Ajeleh, though its course is much more crooked. I find its lower part described in my journal as ‘about a hundred yards broad, winding and extremely rough, with high dyked mountains on either hand; the only tolerable walking to be found is in the tortuous bed of the water channel.’ Three miles from its mouth, the wadi, approaching the foot of Serbal, is reflected sharply to the south-east, and just here there is a fine view of part of the crest, including the highest peak, and of the eastern cliffs of the mountain, which rise in stupendous majesty above this point.

“ Wadi 'Aleyat flows north-west, and is nearly straight from end to <sup>Wadi 'Aleyat.</sup> end. The valley is broad, for a Sinai wadi, in proportion to its length, and slopes very rapidly, rising about two hundred feet in the first mile from its mouth and seven hundred in the third, after which it is lost amid the slopes of Serbal. There are a few shittim and tamarisk trees and bushes of retem towards the lower end, ban trees here and there grow singly in the ravines, and tufts of desert herbage struggle for life among the boulders. In the upper part of the wadi are two small palm-clusters, at an interval of about half a mile, overshadowing springs and pools of cool delicious water; it is just possible to reach these springs with lightly-laden camels by the barely perceptible track which thus far winds in and out among the chaos of the valley-bed. Serbal, rising grandly above the head of the wadi, is seen from the upper springs; but perhaps the very finest near view in the whole neighbourhood is to be had by ascending the adjacent hill side; a photograph we were so fortunate as to secure from the trigonometrical station on this hill gives an excellent representation of the majestic aspect of the eastern end of this splendid pile of granite, its grand serrated crest, and rugged sides riven and split into a thousand ravines and clefts. From the lower half of the wadi, only the eastern part of the mountain can be seen.

“ Wadi 'Ajeleh is narrower and steeper than Wadi 'Aleyat, though <sup>Wadi 'Ajeleh.</sup> about the same length, three miles, and similarly straight, it rises two thousand feet in all, one thousand in the last mile, terminating in a sharp knife-like ridge, 3,978 feet above the sea, with an immediate descent on the other side. The scenery is wild and gloomy; on the east, dark, savage glens pierce the congeries of rugged hills which

occupy the whole central space in front of Serbal; on the west, the cliffs of Jebel Sull'a and Jebel Seraibil es Sugheiréh tower to tremendous heights. But for a rude Arab footpath—the short cut towards Tor, from which the wadi derives its name of 'Ajeleh (haste, or quickness)—the valley would be almost impassable even to pedestrians, its whole bed being piled with huge boulders detached from the neighbouring heights, and torn and scoured in all directions by the ravages of winter torrents. The vegetation, though even scantier, is of the same class as that in Wadi 'Aleyat; the views of Serbâl are different, and confined to the western half of the mountain. Sinaitic inscriptions are abundant in both valleys, as well as in Wadi Nakhleh a tributary of Wadi 'Aleyat, and Wadi Th'mareh on the way to Jebel El Benat.

Gebel Serbal.

“ The summit ridge of Jebel Serbal, about three miles long from end to end, has been frequently described as divided into five principal peaks. When looked at from the usual points of view in Wadi 'Aleyat, it certainly does to all appearance resolve itself into five or at most six massive domes, cones, or turrets. In reality, however, there are many more—ten or eleven certainly, besides several smaller ones, the number seen at any one time varying with the position of the spectator. From the low ground on the north side, the great peaks all appear to be nearly of the same height; the differences are, however, considerable; the loftiest one of all, El Madhawwa, 6,734 feet above the sea, is situated somewhat to the east of the central point of the ridge, but it lies so far back from the spectator on this (the north) side that its superior altitude is scarcely apparent from below.

Views of  
Serbal.

“ There are several spots in Wadi Feiran which afford occasional partial glimpses of the summit of Serbal, hardly less striking than the nearer points of view in Wadi er Rimm and Wadi 'Aleyat. Near the palm-grove of El Hesweh is an effective standpoint, and there are others in the larger oasis above; they admit, it may be, of mere peeps up some little side gully, but of just those peeps which the artist loves to see, with some ridge or shoulder in the foreground to give distance and relief to the towering pile beyond. From the hill-tops north of Serbal the character of the views is exactly reversed, the whole of the noble range from end to end now standing clearly out against the sky, flanked by the scarcely inferior peaks of Jebel Shinenir on the east, Jebel Seraibil es Sugheiréh and Jebel Sull'a on the west. No traveller should fail to ascend Jebel et Tahuneh and enjoy the prospect from its summit; and the adventurous mountaineer, willing to devote a hard but interesting day to the ascent of Jebel el Benat, will be well repaid, not only by a magnificent view of Serbal and an extensive mountain

landscape on every side, but by the sight of the stupendous gorge of Wadi Umfus on the eastern side of the peak, hardly surpassed in the combined grandeur of its rock scenery and beauty of its verdure by any defile in the country.

“ The summit basin of Jebel Serbal, from which the peaks spring, may be reached from Wadi 'Aleyat by one or the other of two so-called <sup>Ascent of Serbal.</sup> paths, the shorter and steeper one ascending by the precipitous rocky ravine called Abu Hamatah immediately beneath the principal peak, the other making a circuitous and gradual ascent by the Sikket Sadur and Sikket er Reshshah. These, as probably the easiest and shortest ways to the summit, are usually selected for travellers by the native guides, but there are doubtless others, known to ibex-hunters. The 'paths' are no more than goat-tracks, if so much. Burckhardt ascended by a narrow cleft behind the spring in Wadi er Rimm, and reached the basin in four hours, 'completely exhausted,' and the summit of the 'eastern' peak in three-quarters of an hour more. It takes from two and a half to three hours, actual going, to reach the highest peak from the upper palms in Wadi 'Aleyat, by the ordinary travellers' routes. The dangers of the ascent by these tracks have been somewhat highly coloured; it is hard and toilsome but scarcely perilous climbing, except when, as sometimes happens, the rocks in shade are coated with a thin film of ice. The principal peak is an enormous smooth dome of granite, so steep and bare in places that, if it were not for the excellent foothold afforded by the coarse surface of the rock, it would be almost impossible to get up and down, there being frequently nothing whatever to cling to. As it is, the difficulties are not great, and, in some of the steepest parts, steps of loose stones, skilfully laid—probably by the hands of hermits or pilgrims long ages ago—still remain to simplify the task. Burckhardt found similar steps on the peak which he climbed, and was told they were a continuation of a regular path ascending from the bottom of the mountain round its south and east sides, probably the identical path up Wadi Rimm el Mahasineh which we followed on a later occasion when on our way to Wadi Sigilliyeh. The extreme summit rock of the highest peak is a smooth cupola of granite, fifteen or twenty yards in diameter, from which a wedge-shaped shelf or promontory projects northward for about fifty yards, at a slightly lower level, to the extreme edge of a fearful precipice which plunges down four thousand feet into Wadi 'Aleyat. On this shelf are seen the ruins of El Madhawwa, 'the lighthouse,' a rude stone structure of which the origin and purpose are described by Mr. Palmer in Appendix I. Several Sinaitic inscriptions were noticed on the summit, and on the path by

which it is approached from the mountain basin. Close to El Madhawwa, in a cave or sheltered hollow formed by weathering, we found traces of inscriptions in whitewash or white paint, in the Sinaitic character, and there can be little doubt they were written by the men who built the beacon-tower, white marks from a similar composition being still visible upon some of the remaining stones, as well as fragments of mortar. Burckhardt describes with a good deal of minuteness his ascent of the *eastern* peak of Serbal, but it is not a little singular to notice how precisely his descriptions of the details seen on its summit tally with those observed by us on the principal peak further to the west the—steps regularly formed with large loose stones, about two feet high, forming a circle about twelve paces in diameter,' the 'inscriptions found on every granite block that presented a smooth surface,' the 'small caverns, large enough to shelter a few persons, with numerous inscriptions on their sides,' and so on. So precise indeed is the coincidence in many minute particulars that, notwithstanding the well-known accuracy of that eminent traveller, it is difficult to resist the inference that he must have been deceived (as, without actual measurements, the most experienced observer might well be in a single visit) by the bewildering character of the summit, and mistaken as to the point he reached. We did not visit Jebel Shinenir, the extreme eastern peak of the range; but there is no peak of Serbal proper, except the highest one, which answers to the above description.

View from  
Summit.

"The view from a Sinai mountain-top is always grand, and well worth the labour of ascent. Like scenery could hardly be met with elsewhere, so wild is it and yet so soft, so desolate and yet so beautiful. That bare rocks, with scarcely a blade of vegetation, could look so soft and beautiful, even in the pure transparent air and brilliant sunlight of the desert, would be thought incredible; it must be seen to be understood. From the summit of Serbal, the landscape on a clear day is one of the most striking and varied, if not the most extensive, in the country. Looking seaward, a wild chaos of rock and mountain fills the foreground; then comes the hot brown El Ga'ah; then Tor and its palm-groves, faintly seen, and the low coast range further north; then the glittering waters of the gulf, backed in the far distance by gray and purple ranges of African mountains. Looking inland, the eye roams over an amazing complication of desert mountains and valleys—a vast network, of which the white and gray wady-beds, winding in fanciful snaky patterns over the whole face of the country, are the threads, while mountains of all sizes, forms, and hues fill the interstices; northward, the far prospect is closed by the long blank line of the Tih escarpment; the peaks of

Katharina and Um Shomer rise darkly in the south-east; at your feet is Feiran, a thin green line of palms straggling through the hills.

“The ruins of Paran and its neighbourhood are described in Oasis of Ferdn. Chapter VII; as also those on the summit of Gebel Sull'a (the noble cliff of smooth gray granite which overhangs the west side of Wadi 'Ajeleh), and the place of sacrifice on Jebel El Moneijah, whither the Bedawin are wont to resort 'to ask the favour of God Most High.' It only remains in connexion with this district, to give a brief description of the oasis of Wadi Feiran. Beginning at the mouth of Wadi 'Aleyat, this beautiful grove extends for about four miles up the valley; date-palm trees, of uncommon size and luxuriance as well as fruitfulness, form the bulk of the larger growth; there are also the tarfah or tamarisk (the manna-bearing tree of the Peninsula) in considerable numbers, the acacia seyal (shittah), armed with fearful spikes, and the sidr which yields a small acrid fruit called nebk; the undergrowth consists of rushes and other marsh plants; and a variety of herbs and grasses, turf, moss, and small flowers carpet the soil in the moister spots. A dry torrent-bed, alternating from side to side, winds through the grove and marks the course and ravages of recent floods. Clusters of rude Bedawin houses, built of loose stones and roofed with palm-boughs, here and there skirt the trees; and sometimes you come upon irregular walled enclosures, containing native gardens of maize and tobacco, which are irrigated with water raised from adjacent wells by means of the simple mechanical contrivance termed a *shuduf*. Bedawin tents may usually be seen peeping out here and there from among the trees; and there are neatly kept native burial-grounds at three or four points in the oasis, one of them containing the tomb of the great Sheikh Abu Shebib, patron saint of the district and a terror to all false swearers. A little stream ripples through the grove, first bursting to light at a point between two and three miles above Wadi 'Aleyat, and now and then disappearing for a short distance as it descends the valley; at El Maharrad it sinks into the gravel, and is never seen again; (the lower grove, at El Hesweh, now contains no running water). The stream is now said to be perennial, though prior to the great seil of 1867, which scoured away many feet of surface soil, there does not appear to have been a never-failing flow. The pass of Feiran is narrow, sometimes but one hundred and fifty yards across, and its rock scenery bold and picturesque; the number of dykes is wonderful, and the rugged cliffs rising six or eight hundred feet on either hand—gneiss and mica-schist, greenstone and granite—display a brilliancy and variety of colour unequalled up to this point

of the march: their nakedness serves moreover to enhance the fresh living beauty of the oasis they enclose. It would be difficult to overstate the pleasure with which after days, or it may be weeks, of the usual desert scenery, the traveller greets this charming defile; one must have marched day after day in the wilderness, over endless tracts of sand, rock, or gravel, sparsely dotted with parched and sickly herbage, to understand the real luxury of a verdant spot like this—its rich foliage and its shade, its running water and moist vegetable soil, its graceful palms and feathery tamarisks, bulbuls and other songsters singing in the grove, blue sky above, and brightly coloured rocks seen through the trees."

When visited in January 1899, shortly after a day and night's heavy rain, this oasis was flooded, being almost impassable for loaded camels. After passing the gardens and palmgroves the heggin had to wade knee-deep in water through narrow channels amongst reeds and bulrushes which in many places reached up to one's face in the saddle. From the lower end of the oasis a strong stream of water was issuing which continued down to El Heswa in a properly kept channel. It thus seems that the water-supply was better than it was when the Survey Officers visited it in 1869.

Tarfa grove.

Leaving the oasis and the palms, the road immediately entered a large grove of tarfa trees, which by their thick trunks and general luxuriance give evidence of the depth and richness of the soil. On either side of the wadi stand mounds of alluvial deposits as much as 30 metres in thickness, sometimes only in isolated blocks near the mouth of tributaries, or again perched high up on the side of the cliff showing vertical faces, and weathering in a fantastic manner. These extend to the lower end of the oasis of Ferân but are never seen afterwards. There they have been evidently used as burial places in early times, as there are numerous caves and openings in them.

El Buwêb.

This tarfa grove continues for two kilometres until near the mouth of Wadi el Akhdar where it dies out. After passing this wadi, the valley undergoes a sudden constriction, due to a neck of quartz-felsite through which the drainage has to pass by a very narrow opening known as El Buwêb, the gate of Ferân. Above this the wadi is called Solâf, where, according to the account of the Ordnance Survey Officers, a grove of tamarisks extending for about four kilometres was swept away by a *sêl* or torrent. The small grove of about 1 kilometre in length must therefore have grown up since then. About a kilometre higher up from this point the Wadi el Sheikh enters from the north-east.

It is now proposed to describe separately the three great valleys—Wadi el Akhdar, Wadi el Sheikh and Wadi Solâf—which find their way to the sea through the gorge of Ferân, beginning with the most northerly—Wadi el Akhdar.

*Wadi el Akhdar.*—This wadi enters Ferân through an opening about 50 metres wide in a ridge of gneiss 250 to 300 metres high containing many dykes. Passing up it over a rough floor of boulders, the gneiss is passed through after a kilometre has been traversed, and immediately after the wadi passes close along the foot of a high, red granite boss, Gebel Yena, on the north, which towers above it in a precipitous front 600 to 700 metres high. It is this boss which forms the plateau of which Gebel Goze and El Banât are the outstanding headlands to the west, and stretching away towards the basin of Rahaba, ends in a precipitous cliff to the north-east, shading off more or less into the gneissose granite in the neighbourhood of El Banât. The surface of this plateau is much streaked with black veins of an acid rock which give it a stripy appearance.

On the south side the wadi is bounded by low hills of gray granite much cut up by red felsitic dykes running in a north-easterly direction. After leaving the gneiss the wadi makes a sharp bend round a headland of the red granite above-mentioned, and after a straight reach of a little over a kilometre, makes a curious U-shaped bend into this plateau, where it receives the two feeders of Wadi Yena, in both of which water is found, the western one being also called Wadi Main. Here the wadi is 200 to 300 metres wide and contains several terraces of sand and boulders. There can be no doubt that the erratic course of the wadi is due to the different hardness of the two rocks composing its sides, and that its course has been determined by the more rapid weathering of the softer rock, thus producing a waterway along the junction line. The same thing is seen in Wadi el Ghadir or Satakh, and Wadi Retema, in both cases formed along junction lines.

*Wadi Satakh.*—This wadi is very wide and open at its mouth, many terraces and mounds of sand occurring in it, and it is very much frequented by the Bedawin who bring their flocks to graze on the plants which grow here and on the plateau. Higher up there is a good supply of water. Ibex abound here, a flock of ten being seen on the hills in the early morning.

*Wadi Retema.*—About 3·5 kilometres from the mouth of the last valley is the entrance of Wadi Retema, which here, together with the wadis Barra, Esh, and El Akhdar, forms the small, open plain dotted with retem called Erwês el Ebêriq (the top of the ground with white patches).

Wadi Retema is a small straight valley which comes down from the mass of red granite between Wadi Barra and Gebel Yena.

*Wadi Barra.*—This wadi takes its origin near the curious conical peak, Zibb el Bahêr Abu Baharia, and flowing south-east slowly becomes enclosed between red granite hills higher on the west than on the east, and gradually narrows and deepens as it descends. About 2·5 kilometres further down, Wadi Erthama enters from the north-east, a small valley in which there is said to be a spring of good water.

A little over two kilometres lower down, Wadi Retema comes in on the same side, and half a kilometre further down the wadi passes out between the two granite bosses—Gebel Retema and Hamra—which form the gate-posts of the valley in a way which gives the name to the valley (the wadi of the passers out). From this to the Erwês el Ebêriq, the valley runs through low hills for about 1·5 kilometres. Throughout its whole length of 8 kilometres or so, the bed of the wadi is excellent going, being made up of compacted granite sand and clay, in which a few retem bushes and many crocuses were growing. Its fall is more rapid than in most other valleys. Down this wadi comes the direct road from Suez to the Dêr at Gebel Musa.

*Wadi el Esh.*—The next valley, Wadi el Esh, is a wide, sandy water-course in which is a considerable Bedawin encampment; in it the head sheikh of the Towara tribe, Abu Nasir, has his home. Retem trees abound, and there is plenty of food for the flocks in the district around. As this wadi nears Gebel Hamra it narrows considerably, and skirting its edge, makes its way rapidly up to the top of the plateau of pink granite where it heads near the source of Wadi Bum, the upper part of Monia, a tributary of Wadi Siq.

*Wadi Solêf.*—Opposite Erwês el Ebêriq, enters the Wadi Solêf (the borrowing wadi) so called because several roads meet here and the Bedawin have the opportunity of borrowing from each other. Up this the Gebel Musa road runs, and drops down into Wadi el Sheikh on the other side of the low ridge separating the latter from Wadi el Akhdar.

From the top of the ridge separating these two wadis, an excellent view of the main mountain system of the peninsula can be obtained. To the west the range of Serbâl rises grandly out of the surrounding country with the rounded conical peak of Bêdhat Um Takha forming its eastern outpost; while away to the south are the dark rounded hill of Madsûs, and the double-peaked crest of Gebel Mareia or Tarbush, as it is named on the Ordnance Survey map; and stretching away further to the north is the massif of Gebel Musa and the hills round

about it, of which Gebel el Gharbi and Watia are the most easily recognized.

From this point onward up this valley, no well-marked drainage comes in until Wadi Harqus is received from the east. This is a fairly long wadi, which taking origin in the wide and undulating Fersh el Elwi el Agramia, and winding in and out among gneissose hill, ridges eventually discharges itself after a course of 10 kilometres into Wadi el Akhdar. There is a well-marked camel track up this valley leading on to the plateau above-mentioned, and thence either into Wadi el Sheikh, or across the fersh of Elwi el Agramia to El Watia.

After leaving the mouth of Harqûs, Wadi el Akhdar makes a fairly straight north-east course through low ridges of gneissose granite for about 10 kilometres when it receives Wadi Hamanier, a tributary which drains the plateau in the vicinity of Naqb Shêqer, but heading in reality at the foot of Gebel Dhalâl. This evidently bears two names as it was named by our guides Wadi Maiat. From this point the wadi turns due east, and after winding about among low hills for about 6 kilometres, reaches En el Akhdar. From this valley the northern route to Gebel Musa crosses El Akhdar straight for the fersh of Elwi el Agramia.

*En el Akhdar.*—This is situated at the foot of the vertical cliff of a boss of porphyritic quartz-felsite, at an altitude of 1,150 metres above the sea. Here there are three wells about 4 or 5 metres deep in all of which is water. There must have been a small village here at one time for there are ruins of several houses and gardens, the walls of which are still standing, and there are the remains of a shaduf for lifting the water from the wells for irrigating the gardens. Looking up the wadi it presents quite the appearance of an oasis, the various palm and sidr trees making a good show of verdure. These wells are much frequented by the Bedawin, being the principal water supply of the vicinity.

A little distance beyond the wells where the wadi bends sharply to the north, there is a fairly large burial ground. In the sandy soil in the bed of the wadi grow numerous lilies, some a delicate purple, while others are pure white, and a few crocuses also occur with them. From this point to its origin in the south-east of Dhalâl the valley is practically on the Fersh el Elwi el Agrami.

This wadi for the whole of its course is fairly shallow-sided and broad, (about 200 or 300 metres) in its lower reaches, and well clothed in vegetation, retem being fairly common in its upper part. Numerous

Bedawin live in the side wadis and possess large flocks of goats, several donkeys and camels, which obtain a plentiful supply of food from the different kinds of plants which grow in the valley and on the plateau.

Wadi  
el Sheikh.

Returning to the mouth of the second great waterway which falls into Ferân, the Wadi el Sheikh, so called because of the tomb of Sheikh el Nebi Sala which is situated near its head, enters about 2 kilometres south of El Akhdar, through an opening in the steeply-tilted gneiss ridge about 200 metres high which extends across the country for tens of kilometres. Here the wadi is about 200 metres wide; as it is ascended it narrows considerably at the same time winding about sharply. Further up, about 2 or 3 kilometres from its mouth, it again widens into a broad valley between low hills of gray granite, which are drained by short, steep wadis on either side. Here also occur some fine examples of terraces which continue for about 5 kilometres up the valley. Seyal trees are found in the lower reaches; but higher up retem bushes occupy the wadi entirely, until near its entrance into the hills round Gebel Musa.

About one kilometre higher up, Wadi Solêf enters from the north, the central road from Suez to El Dêr lying in it. On entering El Sheikh the road splits into two, the path up Wadi Sahab towards Naqb Hawa being only available for lightly laden camels, while that for heavily laden animals follows the main wadi.

Wadi Sahab  
(Valley of  
spreading or  
flowing water).

This is a wide straight wadi which rises rapidly in a south-easterly direction among the low hills which occupy the country between Solâf and El Sheikh. It is between 7 and 8 kilometres long; in the upper third of its course it is practically a plain over 1 kilometre in breadth; and at its head is nearly 300 metres higher than its mouth.

Following up Wadi el Sheikh, which is here a wide open valley clothed with retem, rimth, etc., Wadi Magheirat is reached after a walk of 10 kilometres, a short, wide valley coming from the north-east, at the mouth of which some Sinaitic inscriptions were seen on the right bank. From this point, El Sheikh, which previously had been going north of east, now bends round to east-south-east, at the same time narrowing, and the hills on each side although still low, slope back to loftier peaks about 3 kilometres to the south. On the north, the plateau of Fers el Elwi el Agramia is not over 100 metres above valley level. About

Wadi Hamâta.

11 kilometres above Magheirat the mouth of Wadi Hamâta (the valley of wild figs) is reached, which is about the first important tributary met with since leaving Wadi Sahab. In this valley some wild fig trees still grow; water is found in it; its bed is very rough and makes walking very difficult; and small water-falls and sheer precipices block the way, necessitating the climbing of the hills on either side in order to

go on. Several families of Bedawin live in this neighbourhood, their flocks picking up their food on the hills and in the small wadis.

Near by is the mouth of Wadi Qassab, (the valley of the reed) down which a path comes over a piece of difficult ground from the head of Solêf.

Close by is a Bedawin cemetery, and above this begins the Tarfat el Gidarên, a tarfa grove of over 2 kilometres in length. The trees are the largest yet seen in any part of the peninsula. Tarfat  
el Gidarên.

At the same place the finest examples of terraces, and at the same time the most extensive, begin here and continue up to the entrance of El Watia. They extend some distance on either side of the wadi, and especially on the Elwi el Agramia side.

About one kilometre or so above the tarfa grove, the wadi opens out until it is nearly 300 metres wide, then bending sharply to the south it suddenly narrows into the pass of El Watia.

This is the only means of entrance for heavily-loaded camels into the central mountain area. It is a breach in the precipitous granite ridge of El Gharbi, and is an extremely fine gorge. On either side the granite rises up in sheer precipices, breaking into rugged peaks towering on the eastern side 450 and on the western 600 metres above the valley. It varies from 30 metres in width at the northern entrance to about 100 where it opens out into the plain behind, and is about half a kilometre long, having a firm gravelly floor, and a very tortuous course. On the east side there is a peak somewhat resembling an armchair in shape which the Bedawin call Maqad el Nebi Musa (the seat of the Prophet Moses). El Watia.

Inside the pass the wadi opens out, and the country to the east is a succession of parallel ridges and valleys, which higher up is replaced by hills. The valley here is wide and good going. About 6 kilometres from the pass of El Watia, is the tomb of Sheikh el Nebi Sala, near by which is a large burial ground. Near this point the road to Aqaba leaves the valley on the east. Five or six kilometres further on the wadi divides into two, the Wadi el Sudud and Wadi el Dêr bounding respectively the eastern and northern sides of Gebel el Dêr. The road to Ras Safsâfa (the willow peak) now about 5 kilometres up the last mentioned valley, runs in a south-westerly direction.

The following is a description taken from the Ordnance Survey of Sinai, Part I, of Jebel Musa and neighbourhood:—

“The physical features of Jebel Musa and the country in its neighbourhood are so clearly represented by the photographs, models, sections, and six-inch plans that the task of describing them becomes short and easy. Gebel Musa  
and neigh-  
bourhood.

"The mountain mass of Jebel Musa is nearly a mile broad and rather more than two miles long, and the direction of its longer axis is nearly north-west; on the north-east it is separated from Jebel ed Deir by a deep, narrow glen named Wadi ed Deir, the 'Convent valley'—sometimes also called Wadi es Sho'eib, 'the valley of Jethro'—in which stands the Convent of St. Katharine; on the south-west, Wadi Sh'reich, a still narrower ravine, divides it from the long subordinate ridge of Jebel Fera', which again is cut off by Wadi el Leja from the huge red bluffs of Jebel el Hamr.

"These three mountain masses are composed mainly of red or pink syenitic granite. The profile of greatest elevation descends to the north-west. Jebel el Hamr forms the northern shoulder or buttress of the lofty mountain platform on which Jebel Katharina rests, and is the highest of the three, its loftiest portion having an altitude of 7,519 feet, while the summit peak of Jebel Musa is 7,363, and that of Jebel ed Deir (Jebel 'Aribeh) but 6,739 feet above the sea.

"A conical mountain, Jebel Moneijah (5,987 feet), stands at the head of Wady ed Deir, and is connected by low ridges with Jebel Musa on one hand, and Jebel ed Deir on the other. These two ridges separate the basins of Wady Seba'iyeh and Wady ed Deir from one another, while a third, which joins the south end of Jebel Musa with the neighbouring mountain Jebel Abu'aldi, divides the basins of Wady Seba'iyeh and Wady el Leja. In all other respects Jebel Musa stands alone.

"Wady el Leja, after a north-west course of about two miles, sweeps sharply round the end of Jebel Fera', and under the successive names Seil Leja and Wady ed Deir, passes north-east for three miles along the base of Jebel Musa (Ras Sufsafah) and Jebel ed Deir to Wady es Sheikh, here uniting with Wady es Sudud from the south; it receives on its course Wady Sh'reich and Wady ed Deir (Sho'eib) from the south-east, and the broad wady or sloping plain of Er Rahah from the north-west. Thus the drainage of the whole special survey area, excepting only a narrow strip along the west and north-west edges, passes out near its north-east angle by Wady es Sheikh. Wady es Sudud skirts the eastern and third side of the triangular block of Jebel ed Deir. Two miles above its mouth it takes the name of Wady Seba'iyeh, and continues for about three miles further south to its source in the slopes of Jebel Hadaiyid.

El Fur'eiah.

"Jebel Musa and Jebel ed Deir are confronted on the north by a portion of that great ring or cluster of granitic peaks, known by the general name of El Fur'eiah, which encloses the fertile basin of

Deyset Fur'eah, and forms the northern outpost of the mountain nucleus of the Peninsula. Jebel 'Ajramiyeh (6,296 feet) and Jebel Khizamiyeh (6018 feet) are the dominant peaks in the south of this cluster.

"The summit of Jebel Musa presents the form of a long, narrow Summit of Gebel Musa. trough or basin, enclosed at its sides by a series of comparatively low peaks and ridges, but at its two ends by tremendous piles of mountain, that on the south-east rising into a single-pointed peak 7,363 feet above the sea, while that on the north-west is divided into three or four massive bluffs. The peak at the south-east bears specifically the name of Jebel Musa, 'the mountain of Moses,' and is regarded by the monks as the Mount of the Law, the true Sinai of Scripture; by the Bedawin, who have no tradition of the Proclamation of the Law, simply as the mountain where God spoke with Moses. Its upper portion is of gray granite, weathered externally to a very dark green, and contrasting well with the red granite which lies beneath. On its south side there is a tremendous sheer descent of nearly 1,100 feet to the ridge which crosses to Jebel Abu'aldi, and a further and more gradual fall of 1,100 feet to the bed of Wady Seba'iyyeh; its northern slope descends at a steep angle to the mountain basin 850 feet below. Side by side on its summit stand a mosque, now well nigh in ruins, and a Greek chapel, both built of hewn red granite blocks, the materials of a former chapel said to have been destroyed by the Bedawin; close by there is a small hollow in the solid rock, doubtless produced by weathering, into which, according to the simple Arab tradition, Moses shrank, when the Most High God spoke to him, saying, 'Creep thou into the rock, O Moses, for thou can'st not bear my glory.' The range of high bluffs at the opposite north-western extremity of the mountain basin bears the name of Ras Sufsafeh, from a small willow or Ras Sufsafeh. osier which grows among the rocks, on its south side. From its southern and highest point the profile of the peaks or bluffs descends about four hundred feet to its extreme northern end. All round its north-western face this range falls abruptly to Wady Sh'reich and the Seil Leja, and forms, together with the high bluffs of Jebel Abu T'reif and Jebel Arremziyeh which overhang the Convent valley, a magnificent cliff front some 2,000 feet high, which, as looked at from the north-west, is perhaps the grandest natural feature in the whole Peninsula.

"*Er Rahah*.—The plain of Er Rahah is about a mile and a quarter Er Rahah. in length from its crest to its lowest point near the foot of the Ras Sufsafeh, and half a mile in average breadth, thus containing an area of some four hundred acres exactly facing the mount. Its general inclination

is south-east-by-east  $2\frac{1}{4}^{\circ}$ , or 1 in 26. The surface is of granite gravel, for the most part smooth and even, and plentifully covered with herbs, chiefly '*abeithiran*' and '*shiah*.' Beyond its crest the plain soon narrows, but there is still, for about a mile, a considerable open space (the head of Wady Abu Seileh) of the same character as Er Rahah, and sloping so gradually to the north-west that the cliffs of Ras Sufsafeh are not lost to view. From its lower end, near the foot of these cliffs, the plain merges into the Seil Leja on the west and Wady ed Deir on the east, the one, though more stony and rough than Er Rahah, affording an extensive open space, the other nearly as smooth and even as the plain itself. Ras Sufsafeh is well seen from the Seil Leja, and also from Wadi ed Deir right down to its mouth, these side views, however, do not equal the prospect from the front.

Space for  
encampment.

"In order to estimate the extent of open camping ground which faces the Ras Sufsafeh from different quarters, we may add to the 400 acres of Er Rahah proper, 163 for the upper part of Wady Abu Seileh, 227 for the area more or less level in the Seil Leja, and 260 for the bed of Wady ed Deir, making in all 1,050 acres. To this again may be added about 150 acres of space available for rough encampment on the lower slopes of the hills. So that we have altogether an estimated area of 1,200 acres (nearly six million square yards) in the plains and wadies and their borders, from all points of which the Ras Sufsafeh is not only distinctly seen, but is also the most prominent feature in the landscape; and tents situated in any part of this space might well be said to have been pitched "before" the mountain in question.

Space for  
Spectators.

"As a site from which to witness any spectacle on the top of the Ras Sufsafeh, the plain and hill slopes which face it would accommodate almost any number of spectators. A million persons, at the ample allowance of a square yard each, would occupy about 207 acres, that is, scarcely more than half of the area of Er Rahah at once, and so be able to advance or retire along it at will. Two millions at the same rate would cover the plain from its crest to the nether end of the mountain, but still be able to fall back along the Wadi Abu Seileh without losing sight of Ras Sufsafeh; while in either case large additional numbers might find standing room on the lower slopes of the hills.

View from  
plain.

"The prospect from the plain of Er Rahah is so impressive and sublime that no beholder can fail to be attracted by it. Its beauties moreover gain upon you rather than diminish the more you become familiar with it, and the more it is contrasted with other mountain views; such at least was our experience from a stay of many months in the country, and an acquaintance with every class of its scenery. It

is indeed unrivalled; there is nothing else like it in this or any other part of the Peninsula; the long, wide plain sloping down to the mount, the noble amphitheatre of hills all round, and the bold precipices of Ras Sufsafeh, the 'brow' of Gebel Musa, overlooking and seen from every point in the plain below, the more imposing as it is by far the most conspicuous feature in a landscape where all is grand. The Ras Sufsafeh has a majesty peculiarly its own—a look of stately, I might almost say awful, grandeur, which has stamped it on our minds as by far the most remarkable mountain front in the Sinai Desert. In gazing on that noble cliff and spacious plain at its base, its needs no effort or enthusiasm to recognise their peculiar fitness for the events described in Scripture as having attended the Promulgation of the Law.

"Isolation of Ras Sufsafeh.—There is little or no broken ground at the base of Ras Sufsafeh, where it confronts Er Rahah. Its cliffs, which start suddenly and steeply from the Wady Sh'reich and Seil Leja, become impassable about half way up, and the highest points can only be reached from the mountain basin in their rear. On the north-east they rise almost as boldly from Wady ed Deir, though here they are less inaccessible. On the north-west, the otherwise complete isolation of this magnificent front is slightly broken by the big steep Wady Sh'reich, which, together with the low ridge of Jebel Fera, interrupts the sheer descent on this side into Wadi el Leja, and to some extent mars an effect which, but for this break, would be absolutely perfect. Hence, the view from the head of Er Rahah, at which part Jebel Fera is almost hidden by nearer mountains, is perhaps more effective than that from points lower down in the plain.

"Summit peak of Jebel Musa.—The summit peak of Jebel Musa lies so far back that the Ras Sufsafeh, though more than 400 feet lower, altogether conceals it from a spectator on the plain; indeed, it cannot be seen at all from low ground in the neighbourhood, except from points far up in the side valleys, or others still further south. Wady Seba'iyeh, in its rear, commands perhaps the best of all these views; but the tract of low hills bordering on this valley—that which occupies the space between Jebel Moneijah and Jebel Abu Aldi, and which appears so level when looked down upon from the summit of Jebel Musa that many travellers have been betrayed into describing it as a plain—proves, when examined, to be a sea of rock-strewn hillocks and ravines; and a single glance at the plan or model is sufficient evidence of the groundless nature of any statements to the contrary.

"Water and verdure etc., of the district.—Perennial springs and rivulets of excellent water are abundant on the slopes of Jebel Musa,

Isolation of  
Ras Sufsafeh.

Gebel Musa.

View from  
Wadi  
Seba'iyeh.

Springs and  
streams in  
the district.

and in the neighbouring hills and valleys. Indeed this district has perhaps a more plentiful water-supply than any other in the Peninsula. The Convent of St. Katharine has two copious springs, and there are five or six others in the cliffs above Wady ed Deir, besides small streams in Wady Sh'reich and Wady el Leja, and several springs and wells in the Seil Leja. The streams in Wadies et T'lah, Zawatin and Abu Seileh have been already mentioned; the Deyset Fureiah has a goodly water supply; Mr. Holland found a small brook in a ravine on the east of Wady es Sudud, and there is a spring on Jebel ed Deir opposite the mouth of Wady Um Girsum. These form the principal supply in the immediate neighbourhood of Jebel Musa, and there are others, too numerous to mention, in the surrounding hills and valleys. Pasturage also is fairly abundant in this district; the Deyset Fur'eiah, one of the largest and most fertile mountain basins in the country, is fruitful with desert herbs and grasses, and much resorted to by the Bedawin; and there is a goodly sprinkling of fragrant herbage, affording nutritive feed for camels and goats on many of the mountain sides, notably on the upper slopes of Jebel Katharina, which at some points have almost the appearance of well-clothed downs.

Pasturage.

Monastic  
Ruins.

"Monastic buldings, most of them in ruins, are very numerous in the valleys immediately surrounding Jebel Musa and on the sacred summit itself; cells and chapels, nestling amongst the cliffs and rocks, meet the eye at almost every turn, and Wady el Leja contains the ruins of two branch convents.

Gardens.

"Gardens, still beautiful and fruitful though sadly neglected, surround some of the larger ruins; the gardens of the deserted convent of El Arba'in, in Wady el Leja, is about 15 acres in extent, or more than twice as large as that of St. Katharine's, and there are several others of a goodly size in the valleys west of Ras Sufsafeh. The monks, though still claiming the rights of proprietorship over these old gardens, and extorting a small annual percentage of produce from the Arabs who rudely tend them, unfortunately take no steps to ensure their proper cultivation.

"It is not only in the immediate vicinity of Jebel Musa that the monastic remains are to be seen. Nearly every available spot in the hills and valleys for miles round seems to have been taken advantage of; wherever water and the smallest scrap of open ground are found, you are almost sure to come upon these ruins and the vestiges of former cultivation. I have already mentioned the rich fruit groves of Wady et T'lah, the most fertile by far of all the valleys in the central cluster; numerous gardens and ruins dot the Deyset Fur'eiah and the

hills around it; and in Wady Gharbeh, just below the point where it breaks from the mountains, there is quite an imposing cluster of similar remains, with numbers of date-palms and a stream of cool delicious water.

“*Wadies*.—The wadies which surrounded Jebel Musa on the east, <sup>Wadies.</sup> west, and south are extremely wild and rocky. Wady el Leja is filled with enormous fragments and boulders of granite; Wady Sh’reich is even worse towards its mouth; from the chapel of St. Pantaleemon there is a steep rise of six hundred feet in half a mile over tremendous piles of rocky debris from the cliffs of Ras Sufsafeh; but higher up, the valley is more smooth and level. In Wady ed Deir, as far at least as the Convent, there are fewer boulders and better walking, the path lying in many places over the bare solid rock which forms the wady-bed. There are several Sinaitic inscriptions in Wadies el Leja and ed Deir.

“*Paths up Jebel Musa*.—The summit basin of Jebel Musa may be reached by either of five paths or tracks, as follows:—

“(1) The sikket Syedna Musa, or “Path of our Lord Moses.”—This <sup>Paths up Gebel Musa.</sup> route, leaving the Convent in a southerly direction, climbs the mountain side by a steep ravine, and reaches the basin at Elijah’s Chapel, close to the foot of the peak of Jebel Musa, after an ascent of about 1,500 feet. It is the track, which has been followed by monks and pilgrims for many centuries, past a rude flight of rocky steps, formed of huge slabs of granite arranged with considerable skill, but now destroyed at many points by the fall of rocks or rush of torrents. Its course lies amid the wildest and grandest natural features, tremendous masses of fallen granite, towering precipices, and mighty peaks and pinnacles of rock. Several objects of legendary interest are passed on the way; the Ma’yan Musa or ‘Spring of Moses’ rises to the surface in a cool shady rock grotto about four hundred feet up the mountain side; it is said by the Bedawin to be the identical well at which Moses watered Jethro’s flocks; the monks tell you it was miraculously created for the benefit of St. Stephanos, a former cobbler hermit who lived here. Five or six hundred feet higher up is the chapel of the Virgin of the Oeconomos, built in commemoration of the supposed miraculous extirpation of fleas in the Convent, which forms the subject of a well-known legend. Between this chapel and the summit there are two fine arches; then the mountain basin is reached.

“(2) The sikket el Basha, or “Pasha’s road”.—This road was begun by Abbas Pasha who did not live to see it finished; though in places out of repair, it is for the most part in fair condition and still passable for camels. Ascending Wady ed Deir to its source in the

ridge which connects Jebel Musa with Jebel Moneijah, it winds in long steep zig-zags up the south-east face of Jebel Musa, and ends abruptly just at the edge of the basin, at a point a little above Elijah's Chapel.

"(3) The sikket Sho'eib, or "Path of Jethro".—A very precipitous rocky ravine, containing only the faintest traces of a path, which ascends from near the ruined barracks in Wady ed Deir, and reaches the basin at the back of Ras Sufsafteh after a climb of about 1,500 feet.

"(4) A rude winding track which ascends the western cliffs of Jebel Musa to the mountain basin from a point about two-thirds of the way up Wady Sh'reich, and, according to an early tradition, is the path formerly used by Moses.

"(5) A winding path, less rocky and precipitous than the Sikket Syedna Musa, which rises from the convent of El Arbain in Wady el Leja to the south-west corner of the mountain basin. It was probably constructed for the use of pilgrims, and is constantly followed by them in descending from Jebel Musa on their way, in the usual circuit, to the Deir el Arbain and Jebel Katharina.

View from  
Summit.

"From Elijah's Chapel, a further flight of steps, like those on the Sikket Syedna Musa, leads on to the summit peak of Jebel Musa, passing a little way short of the highest point the mysterious "camel's footprint" in the solid rock. The prospect from the summit is magnificent, being limited on the west and south-west only by the mountain masses of Jebel Katharina, Jebel el Hamr, etc. It is quite incorrect to say, as has been often declared by travellers, that the Gulf of Suez can be seen from this point.

View from  
Ras Sufsafteh.

"To reach the highest peak of Ras Sufsafteh from the chapel of Elijah, there is a rough scramble for a mile or more along the mountain basin to the back of the bluff, over a rugged path, now ascending, now descending, and passing in and out between enormous domes of granite; then a breathless climb of three or four hundred feet up a steep, rocky ravine which divides the two westernmost bluffs, till at last, on reaching its crest, situated in a deep narrow cleft between tremendous walls of rock, you come suddenly into view of the plain of Er Rahah. But, fine as is this prospect, a still finer one awaits the traveller who ascends the rugged cliff on his left hand to its topmost point, the highest in the whole range of bluffs. It is a noble panorama, and has often been described by able pens. In front, the long gray plain of Er Rahah sloping down from its crest more than two miles away to its base 2,000 feet beneath your stand-point, and enclosed between long ranges of stately hills, which extend far back along the line of

the Nagb Hawa ; below, the curious curved mound, Ujrat el Mehd, forming a kind of natural amphitheatre which exactly faces the mount ; behind, the rugged basin of Jebel Musa ending in the traditional peak crowned by the memorials of its double sanctity ; and around, on all sides, a stormy sea of mountains of indescribable grandeur. No one can gaze unmoved on such a landscape ; and its natural wonders are heightened in their effect on the beholder's mind as he thinks upon the great scenes of the Proclamation of the Law, once enacted, probably, upon this very spot.

“ The Cluster of Jebel Katharina.—South-west of Jebel Musa, three conical peaks rise from the north-western ridge of that great mountain mass of syenitic granite which forms at once the kernel and the culminating feature of the Sinai Peninsula. Jebel Zebir—which is interpreted to mean “The mountain on which God spake to Moses”—8,551 feet above the sea, is the central and highest of the three. Jebel Katharina, so called from the monastic legend that St. Katharine's body was brought hither from Alexandria by angels, comes next in altitude, being but 25 feet lower ; it lies half a mile to the north of Jebel Zebir. The third and lowest, Jebel Abu Rumail, is a mile south of Jebel Zebir, and has an altitude of 8,427 feet. Further south, the mountain mass expands into an undulating fersh, or upland plateau, the entire summit area being about twelve square miles, and here and there rising into dark, shattered peaks which overhang the surrounding valleys. The most remarkable of these is Jebel Koli, a sharp pinnacle or cusp at the southern end 3,236 feet above the sea. The exposed cliffs and peaks are dark, almost black in colour, thus imparting a sombre character to the scenery. Jebel Um Iswed, “The Mountain of Blackness”, on the south-west, owes its name to this peculiarity.

“ Jebel Um Shomer (8,449 feet) had, prior to our survey, been supposed by many to be the highest, and Jebel Katharina the next highest, peak in the country. The latter mountain, however, has the superiority by about 77 feet, and Jebel Zebir, which no one seems to have thought of, outstrips them both.

“ Ascent of Jebel Katharina.—The path from St. Katharine's leads up Wady el Leja as far as the Convent of El Arba'in. On his way round the foot of Ras Sufsafeh, the traveller passes several objects connected by absurd monkish legends with events described in Scripture, and grouped, without regard to facts or probability, within a pleasant walk of the Convent gates ; such for instance, are the Mould of the Calf, the Burial-place of the Tables of the Law, and the Cave of Korah, Dathan and Abiram : also in Wady el Leja, about

half way up, the so-called "Stone of Moses" (Exodus xvii., 6), one of scores of rocks of a similar size, and kind scattered up and down the wady. At the Deir el Arba'in, he turns south-west along the Shagg Musa, a dark, rocky glen which runs far up into the north-eastern slopes of Jebel Katharina. A mile or so further on, the path leaves the bed of the ravine and henceforward to the foot of the last rocky ascent of the summit cone, it is a tiring heavy climb up an abrupt and crumbling mountain side; when covered, as in winter they sometimes are, with snow, these slopes are extremely difficult of ascent. A beautiful spring, Ma'yan es Shinnar, the "Partridge fountain" is passed on the way. The summit peak is a huge naked block of syenitic granite, descending somewhat steeply on all sides, but so broken into clefts and ledges that there is no danger or difficulty in climbing it. A little chapel, of the usual kind, dedicated to St. Katharine, crowns the topmost block.

Ma'yan es  
Shinnar.

View from  
Summit.

"As its peak is all but the loftiest, so is the view from Jebel Katharina one of the finest in the country. From this high and freezing standpoint you may, on any clear day, look down upon three-fourths of the Peninsula of Sinai, from Jebel Hammam Far'un on the north-west to the mountains of Wady el Ain on the north-east; from Jebel Musa and Ras Sifsafah, which seem quite close to your side, and the labyrinth of monster mountains spread out like a model at your feet, to the glimmering waters of the twin gulfs and the hills of Arabia and Africa beyond them on either hand. Jebel Zebir and Um Shomer slightly spoil the view southward, and little can be seen beyond the Tih escarpment on the north; but in all other quarters the prospect is most extensive. Ras Muhammed is not to be seen, though you can trace the two arms of the Red Sea almost to their point of junction.

"The whole prospect is magnificent, grander even than that from Serbal; the effects of colour, light, and shade excite the admiration of every traveller; the colours on land, sky, and sea are simply enchanting, and the intense stillness and silence of the desert lends mystery and solemnity to the scene. But it is at sunrise or sunset that a Sinai mountain landscape is seen to its greatest perfection. Perhaps the hour of sunset is to be preferred to any other. Then you have orange, pink, green and blue in the sky, indigo, lilac and rich red brown like burnished copper on the hills, colours ever changing and deepening, shadows ever lengthening, as the sun slowly declines."

Country  
between  
El Sheikh  
and Solaf.

Returning down Wadi el Sheikh to the mouth of Wadi Qassab, the path connecting this wadi with Solaf on the left is taken. On the

watershed from the top of any of the rounded peaks a good view of the country enclosed by these two valleys is obtained. On the south it is bounded by the red granite range of El Gharbi which rises abruptly from the terrace-covered plain. From the foot of this ridge the ground slopes up to a group of rounded, pink, granite hills of which Gebel Hamâta forms the summit. From this group the ground slopes down on all sides, while northwards, ridge beyond ridge of dyke-centred granite extend right up to the edge of Wadi el Sheikh. Especially noticeable is this dyke system to the north of Gebel Moreia or Tarbush from whence these dykes radiate. Had it not been for their presence this area would have been, in all probability, reduced more or less to a dead level.

Passing down into Wadi el Gharbi, which heads in the mountain mass of Matab el Dêr, a tarfa grove of well-grown trees as well as some palms are found in its narrow sandy bed. Higher up there are a few ruins. A little further down is the path going to Naqb Hawa, which here descends a steep slope of one of the many terraces round about. Just beyond the entrance to the Naqb is the very narrow opening of Wadi Emlêsa, a gigantic winding defile, which, piercing far into the heart of the central mountain cluster, has its extreme source in the north-western slopes of Gebel Katharina. "Though passable to pedestrians only this wild romantic gorge deserves description as an example of the most beautiful of the mountain glens of Sinai; indeed it exhibits almost from end to end of its course a combination of grandeur with beauty seldom met with elsewhere in the country. The entry from the plain south of Wady Solaf into the hills is very abrupt, and you suddenly find yourself in a narrow, wild glen but fifty yards across, hemmed in by towering granite mountains from 1000 to 2500ft. in height. In about a mile from the mouth of the gorge, you come to a faint trickling stream fringed with abundant vegetation, wild fig trees, palm trees, high rushes and reeds; there are also old monastic dwellings, surrounded by gardens now fallen into Arab hands. As you ascend the defile, its verdure grows more and more abundant; the faint stream becomes a gladsome rivulet, here falling in spray over huge boulders or ledges of solid rock, there spreading into deep green rocky pools amid a profusion of ferns and mosses; the wady in its narrowest part is a mere cleft between gigantic overhanging walls of rock which stand in stupendous contrast to the palms and gardens in its bed; and the whole scenery, both of the gorge itself and of the deep, gloomy defiles which here and there enter from the south, abounds with features of remarkable grandeur. The vegetation reaches its highest pitch at and

near the point where Wady Bugiyeh flows in from the neighbouring pass of Nagb Hawa. Here the gardens and monastic ruins are extremely numerous; the sylvan aspect of these gardens, always beautiful, is especially so in the early half of the year, when the numerous varieties of fruit trees, bright with fresh spring and summer foliage and blossoms, present the appearance of a perfect Paradise in the midst of these savage wilds. The name of the main defile, Wady Emleisah, 'the slippery valley' (from its boulders polished by the flow of water), and that of its branch, Wady Bugiyeh, 'the valley through which water rushes with the noise of a trumpet,' are sufficient to prepare the traveller for his rough and tiresome scramble along its bed, torn and ravaged by the floods. But, from a short distance below Wady Bugiyeh, an old monastic path, still plainly marked, and in some places in capital preservation, ascends the glen and vastly aids one's progress. About two miles above Wady Bugiyeh, the valley, here bearing the name of Wady et T'lah, bifurcates; the principal and fertile branch, turning southward into the hills soon subdivides into a number of small channels, which wind up the slopes of Jebel Katharina and Samr et Tiniyeh to their sources; the other branch, scarcely a mile long, and which the old road follows, terminates in a steep rocky nagb, with an immediate descent from its crest into the Seil Leja, within a mile of the Ras Sufsafeh cliffs."

Wadi et T'lah.

Wadi Solâf.

Leaving the entrance of Wadi Emlêsa the road leads down Wadi Solâf, a nice broad valley bounded near the head by terraces. On its right it receives several small tributaries from the low hills and open ground which compose the country between it and Wadi el Sheikh, among which are Wadi Niqwat el Amri, named after a person of that name, Wadi Qirit el Maghaddi (the valley of the village of the merry-maker), Wadi Qaban and Abu Talib, the latter named after the successor of Mohammed, while from the left it receives Wadi Emlêsa from Samr el Tinia, Wadi Hamâra from the hills north of Gebel Moreia, and Wadi Magrifat from the Fersh el Dhabb (the lizard's plateau).

The wadi affords excellent going and is clothed with a luxuriant growth of retem in its lower part, while one or two seyal grow higher up. Other plants, affording abundant food for the flocks of the numerous Bedawin who live in this wadi, grow here and on the open ground to the right. On the left rises the tripartite summit of Gebel Moreia or Tarbush, while stretching away to the west of it rise the sharply tilted ridges of gneiss ending in the neighbourhood of Gebel Ethmed and Naqb el Engawa, so-called because the dates from the palmgrove at Tor are brought to the Convent by this route. On the

right it is bounded by Gebel Um Esnân (probably named because it is much cut by black dykes, these being called "Sunn" by the Bedawin). Beyond this the right bank is bounded by the ridge of gneiss which was mentioned as occurring at the mouth of Wadi el Sheikh. Before reaching the Naqb el Engawa, the wadi, which up to the present had been following a fairly straight east-and-west course, now bends sharply north-west, then south-west, and after passing the tributary from the Naqb, bears away in a tortuous north-west course toward Ferân.

From the left it receives Wadi Um Takha from Bêdhat Um Takha, the only other tributary of importance being Wadi el Rim, which enters from the same side about 3 kilometres from its mouth. Below this the wadi narrows considerably; while above, it varied between 200 and 300 metres in width.

"Branch route to Wady Sigilliyeh.—It is about an hour's walk up Wadi er Rimm Wady er Rimm to the monastic remains at the bend of the valley; here the wady becomes impassable for camels; but from traces seen higher up, there can be no doubt that at one time an excellent mountain path extended beyond this point, leading ultimately to the now deserted and ruined monastic settlements near the head of Wady Sigilliyeh; we visited these ruins, and I subjoin a few notes of our trip, extracted from my journal. From the spring in Wady er Rimm, a walk of about a mile and a quarter up the valley, over frightful boulders, brought us to the mouth of Wady Rimm el Mahasineh; we now turned to our right, nearly south-west, and followed this valley, or rather glen, to its Wadi Rimm  
el Mahasineh source, three miles distant, on a rocky plateau on the eastern shoulder of the Serbal range; the glen is rough, steep and tiring, and piled with rocks and boulders, and ends in a precipitous ascent; traces of an old monastic road, well graded and in good preservation, were sometimes seen, though floods have destroyed the greater part; there were palms and trickling water in two or three places; also a few Sinaitic inscriptions, but these ceased at the foot of the last ascent, and afterwards no more were seen. On the summit, about 5,075 feet above the sea, we found ourselves in the midst of wild and awful scenery; huge shattered cliffs and peaks of granite rose on our right and left; to our right Jebel Shinenir, on the eastern flank of Serbal; to our left, Beidhat Um Takha, Jebel Sigilliyeh, and others no less grand; beneath and before us a number of precipitous glens and ravines descended from the surrounding heights to a principal channel, Wady Sigilliyeh, which winds seaward in a deep chasm between massive granite mountains. There is a ruined building, doubtless monastic, on the summit plateau, built probably as a resting-place for weary hermits. Just beyond it,

Wady  
Sigilliyeh.

we plunged into a narrow ravine, falling at a tremendous angle into Wady Sigilliyeh, twelve hundred feet below. A more desperate spot for a road can hardly be conceived; it was one of the toughest pieces of mountain travel we had yet encountered; but the early monks, with an energy almost incomprehensible, had constructed an excellent path, arranged in steps and winding down the rugged slope; wherever the cataracts have spared them, these ancient steps are still intact, large flat slabs of granite skilfully and securely laid. Half way down, the steps failed us; here the floods had swept away every trace, and we had to pick our way with difficulty, and often danger, to the bottom of the ravine, amid crumbling debris and over treacherous slides of loose friable alluvium. Crossing the wady at the foot of the descent, we immediately began to mount the opposite hill-side by a continuation of the ancient path, here in a fair state of preservation, and graded with admirable skill and judgment along the steep rocky mountain ledges. Twenty minutes hard walking, and an ascent of about five hundred feet from the wadi bed, brought us to the head of a sequestered glen; and here, amid palms and wild rocks, with a tiny spring just above, trickling amongst maidenhair ferns, were the remains of one of the so-called "convents" we had come to see, consisting of no more than two or three monastic cells and gardens, all in ruins. Half a mile along the hill-side we came upon another glen and just such another cluster of ruins; and across on the opposite side of the wady, could be discerned a third and similar group, approached by a path graded along the mountain's face like that we had just ascended. The ruins are unimportant, and only interesting as having once formed the abodes of recluses so fanatical as to have made their homes in this weird inaccessible spot. But the scenery was most impressive—almost overpowering—the stupendous mountains, the utter seclusion and death-like stillness and the strangely picturesque mixture of desolation and verdure. We had a hard and weary scramble home to our tents in Wady er Rimm, three and a half hours' steady going, with but one short halt at the head of the great ravine. Our day's exploit amazed the Bedawin in camp; even Salem, our hardy guide was obliged to admit fatigue; the sheikh, Hassan Ibn Amir, evidently thought us fools for our pains, and remarked that, Arab though he was, if anything could have induced him to go so far, nothing certainly could have persuaded him to go and return in a single day."

Leaving Wadi Solâf at the Naqb el Engawa, after a walk of 2.5 kilometres, the head of Wadi Hebrân is reached, here 1,002 metres above the sea, and the water from this point makes its way down a rugged





PALM GROVE IN WADI HEBRAN.

pass into the main waterway of Hebrân. The road down to the main wadi is very bad going, being for the most part a narrow, winding, rocky path along the ledges overhanging the pass, and very difficult for loaded camels. At the water-parting there are numerous ruins called "nawamîs."

Descending the gorge from the Naqb, one sees the steep jagged peaks of Matak el Barûd on the right, while on the left the ridges of gneiss rise one behind the other to the foot of Gebel Moreia, a doleritic neck split up into three peaks, which stand 2,050 metres above the sea.

As the wadi opens out from the pass it receives Wadi Moreia from the left, and opposite it Wadi Um Lassaf—so named because of the lassaf trees growing in it—from the ridge of Matak el Barûd.

At the point where the valley bends round to the south-west it receives Wadi Ethmed, the important tributary of Ethmed (so called because its water disappears in summer), which supplies a large quantity of the water which comes down Hebrân, its collecting ground being in the gneiss hills between Wadi Hebrân and Gebel Moreia. A little further down two other feeders come in from the left, viz, Wadi Morêta and Wadi Tayiba, the former heading in the large mass of red granite, Gebel Baghabuq, which lies between Gebel Madsûs and Moreia, while the latter takes its origin at the foot of Gebel Tayiba, an outlying part of the above-mentioned mass.

This is a fine wide wadi, also from the left, in which several goodly <sup>Wadi Kibrîn (Gabriel's Valley).</sup> seyal are seen growing. It heads in Gebel Baghabuq, and running along the foot of Gebel Madsûs, bends north-west and enters Hebrân. At its mouth on its left side there are a few sinaitic inscriptions seen <sup>Inscriptions.</sup> on a large detached block of grey granite.

About 4 kilometres further down, the Wadi Khalaqa (name a corrupt <sup>Wadi Khalaqa.</sup> form of Khirqa, a fissure or rift) a very narrow valley with small precipices in it, enters from the right, its source being in Gebel Matak el Barûd. Beyond this some very well-grown seyal trees were passed, and then Wadi Wêber entered from the left from its source in the hills between Wadis Hebrân and Meâr.

A little further down Wadi Emlaha enters from the right. It <sup>Wadi Emlaha.</sup> receives its name from the brackish water found in it. About 4 kilometres further down Wadi Khurr (i.e., a channel caused by the continual dropping of water) enters from the left from Gebel Khurr. Down to this point the main wadi has been fairly wide and straight, its width varying from 80 to 100 metres between fairly steep sides of grey granite. From its head down to about 9 kilometres from its mouth the wadi is occupied mainly by seyal trees. Below this point, tarfa and

palms take their place, while running water appears. In many places the tarfa bushes fill the wadi, while a few lassaf are seen on its sides. The stream occasionally opens out and forms nice little clear pools in which *Veronica beccabunga*, reeds, bulrushes, mint, and a few other plants grow. About 4 kilometres from its mouth the valley narrows to about 40 metres, and becomes a winding gorge, which in many places is less than 20 metres wide, while the going is rather rough amongst sand and boulders. This character may be said to belong to the whole wadi, the road being much improved where the Sikkat Abbas Pasha, which runs along it still remains intact. Towering over the gorge are precipitous cliffs 150 to 200 metres high, on those sides marks are seen showing how high the winter torrents occasionally rise.

Climbing a hill above this pass, a good view of the surrounding country can be obtained. To the north, in the foreground, one notices Gebel Illimiana, between which and Gebel Wirqa the Wadi Wirqa enters the plain. Beyond Wirqa is the plateau-like mass of granite, the Fersh el Ramûz; while further to the north is the red granite mass of Gebel Siqillia with Gebel Serbâl towering behind. On the north-east, Gebel Moreia with Gebel Madsûs on the east, form the two prominent features of the landscape; while away to the south stretches the high plateau of hills which culminates in Gebel Um Shomer. The hills bounding Wadi Hebrân are mainly composed of grey or pink granite which is much cut by dykes; while away to the north, gneiss hills form the green plateau which is called the Fersh el Dhabb.

It is now necessary to diverge from the direct line followed hitherto to give a short description of the hills and wadis which lie on the border of Qâ between Hebrân and the limestone plateau to the north-west.

Wadi  
Illimiana.

Passing north the first wadi reached is that of Illimiana, only a short valley heading in the hill bearing its name.

Wadi Wirqa.

The next is that of Wirqa which is a more important drainage line. From the top of Gebel Wirqa, which is 994 metres above the sea, the course of this wadi is seen plainly. Near its mouth it has the gorge which characterises so many of the wadis which enter El Qâ, but after passing through the granite band it enters a patch of low hills where it opens out. In it were seen water, palms, and seyal trees. At no part of its course did it seem to be very wide, but it receives a large part of the water from Gebel Siqillia on its way from its head in the Fersh el Dhabb.

Wadi Ramûz.

The next wadi to the north is that of Ramûz, the name meaning a secret spring. This is a short wadi which heads behind Gebel Ramûz in the Fersh Ramûz. In it are a few palms and a small but good well

of water, while a little further up, the way is blocked by a precipice of granite about 13 metres high.

Between Wadi Ramûz and Wadi Geba rise the hills of Ramûz, 800 <sup>Wadi Geba.</sup> metres, and Geba, 933 metres above sea level. In this valley there is a perpetual stream of water running over the waterfall at its mouth.

"This wadi presents from end to end of its course a scene of uncommon magnificence and beauty. At its mouth giant cliffs frown down upon a narrow chasm, in many places scarcely thirty feet in width, through which the drainage of nearly the whole southern slopes of Mounts Serbal and Sigilliyeh breaks by a succession of leaps into the plain below. The scenes here at flood-times must be almost terrible. As we saw it, the stream was no more than a trickling rivulet, with large pools every here and there; but the smooth waterworn appearance of the cliffs for twenty or thirty feet upwards on either side of the pass, and widespread signs of devastation in the plain beyond, served to convey a faint idea of what those scenes must be. Higher up, the valley expands into a wild romantic glen, hemmed in by naked granite mountains of stupendous height. A pavement of pink or grey granite, polished by the rush of waters, forms its bed, and piles of monster boulders here and there encumber the path. A clear perennial stream winds down the ravine, now rippling over smooth slabs of rock, anon spreading into deep green pools, or falling over boulders and ledges in tiny cascades which sprinkle numbers of ferns growing in shady rock grottoes with their foam. For want probably of sufficient soil, there are no palms in the valley, but an abundance of marsh plants, bright green herbage, and waving rushes ten or twelve feet high, flourish by the brook side. The whole scene is a charming strange mixture of the savage and the peaceful. Every bend in the glen reveals some new and surprising prospect; at every turn you pause to admire the bold forms and glowing tints of the surrounding mountains, and the grand rugged cliffs of Serbal closing the distant view. From the blank and horrible desolation of El Gaah, to come suddenly into a valley so beautiful as this, with shade, water and verdure, and majestic features of scenery, is a treat of the rarest kind. As if to complete the contrast, signs of life are here abundant and add much to the romantic loneliness of the scene; footprints of leopards mark the gravel by the water's side in such numbers that one cannot help wondering how so many of these creatures can possibly find subsistence in the desert; tracks of ibex, too, are very numerous; little brown desert partridges scurry over the naked rocks; and locusts, dragon-flies, and winged grasshoppers of enormous size, skim through the air."

Wadi Meâr.

Returning south again, the next wadi below Hebrân is that of Meâr. The mouth of this wadi is filled with boulders, and is very rough indeed. Out in the plain deep ruts have been cut by the torrents, and a huge mass of boulders is piled up, round which the water makes its way in different channels. At first the wadi is fairly wide, but it very soon narrows into a gorge with perpendicular sides of a dark diorite, 300 metres high, veined in every direction by white granite, being cut as well by dykes of dolerite and quartz-felsite. Here the gorge is little more than 20 metres wide. Just above the gorge the wadi widens suddenly, and one comes on several streams of running water which suddenly lose themselves in the sand. In the middle of the wadi, slightly above the water, is a fine grove of well-grown, spreading seyal trees which is evidently much used as a camping place by the Bedawin. On the right side of the wadi are several small enclosed gardens, which are watered by shaduf from the stream near by; palms and various vegetables being grown there. Besides the palms, there are sidr trees of great size, groves of tarfa bushes, and numerous representatives of the "*ilban*" (Towara), "*yessar*" (Maazi) and "*moina*" (Ababda) whose great resemblance to the mountain ash made it an ornament to the valley. For about 5 kilometres up, the wadi was filled with tarfa trees, which practically obscured all the view, but beyond this point they were replaced by the "*ilban*". From the gorge upwards the wadi varied from 100 to 200 metres wide, and the bed was rather rough and bouldery, there being only the faintest path visible.

Wadi Meqênus.

On the way up a few unimportant feeders were passed, the largest of which was Wadi Ghueb. But the first important tributary is that of Wadi Meqênus (the hunter's valley) which comes in from the left bank from behind Gebel Meqênus. It is a rough wadi impassable for camels, and filled with huge boulders and cataracts over which one has to climb. The sides of the hills here bear a few small trees and shrubs; of the latter one was a spiny plant with two small rosettes of leaves to each spine called "*oshad*", while the other resembling "*arta*" is called "*alda*". Several pools of water were found in this wadi as well as numerous "*ilban*" trees. Gebel Meqênus, which is 1,007 metres above the sea, is evidently the turning point of the water between Meâr and Ilti, as all the streams go down from it into the latter.

Wadi Ilti.

Between Wadi Meqênus and Ilti the main wadi is fairly straight. Near the mouth of Wadi Ilti, Meâr widens out, a large terrace marking the junction between the two wadis. Wadi Ilti near its mouth has a westerly direction, but after winding in and out amongst huge boulders of granite for a little, it suddenly bends round until its course is almost

due north and south. Here it is better footing but very sandy, and after going through a narrow pass of rock it opens out somewhat, the hills on either side being less steep and high. Just above the pass the wadi makes a U-shaped bend and then bears off to the south-east; pools of water in smooth rock basins were seen, with a babbling stream feeding them; while around them are numerous bulrushes and palms, and near by are some old ruins. Higher up the wadi, which was no longer passable for loaded camels, were several clumps of palms up to which a footpath led along the side of the hills. After passing Gebel Sawasia this wadi rose rapidly and soon ended in the side of Gebel Ilti.

To the east of this wadi rises Gebel Sawasia, a high hill composed of granite at the base, but terminated by a steep neck of dolerite at the top. Climbing it, it was found that where the granite ends and the dolerite begins the sides are almost sheer up and down, very slippery and polished so that it could only be ascended on hands and knees. This hill is evidently the Gebel Ilti of the Ordnance Survey, but apparently they have gone somewhat astray here, as a large wadi is also shown which does not exist.

By the Ordnance Survey the height of this hill was given as 6,480 ft. or 1,975 metres. On its eastern side it overlooks Wadi Khrêta, ending in a sheer precipice 1,280 metres high. From the top of this hill a good view is obtained of the surrounding hills. To the south could be seen Gebel Shiddiq, and beyond it Gebel Um Shomer, which, from this point of view, does not look very imposing, the surrounding hills taking away from its height; while to the west are seen Gebels Meqênus, Ilti, and Abu Hagab, forming a sort of plateau sloping up and ending in the ridge of Wiqran and Giddet el Ela (the mountain of high dykes). The upper portion is much cut up by well-marked black dykes (called "giddet" by the Bedawin); to the north the plateau-like character is continued beyond Hebrân, until Gebels Illimiana, Wirqa, Siqillia and Serbâl suddenly break the general level of the surface; while bearing round to the west are Gebels Tayiba, Madsûs, with the peaks of Moreia in the distance, Baghabuq and Um Saha occupying the foreground, the latter coming almost up to the side of Wadi Khrêta. Beyond the jagged mass of Um Saha and forming the skyline, could be seen Gebel Qasr Abbas Pasha (Samr el Tinia of the Ordnance Survey) with its ruined palace clearly visible, Gebel Katrîna, Zebir, and Abu Rumêl, while nearer is the black range of Koli and Um Iswed, which approaches and eventually forms the wall of the Wadi Siq on the north and Khrêta on the west. Returning down Wadi Ilti, at the point where it meets

Meâr, there is a bold spur from Sawasia which ends more or less perpendicularly, and is continued up the wadi until, opposite Gebel Madsûs, it forms a steep, overhanging cliff.

Gebel Madsûs. This is a large black hill with a rather blunt top, its sides much seamed with ravines, and so steep as to render it inaccessible from Wadi Meâr. It is composed of a neck of dolerite and it is to this that its inaccessible nature is due. The drainage from it is brought down by Wadi Rahu.

Nearly south-east from Gebel Madsûs, Wadi Meâr bends round from its east-and-west line towards the south-east, and makes its way over bouldery, rough ground along the foot of Gebels Um Saha and Hamêdha, where there are numerous high terraces of piled up boulders, evidently the work of the various tributaries which come in from the right bank.

Wadi Siq. A little farther on Wadi Meâr ceases, having split up into two branches, the main one continuing in the same course being called Khrêta, while the other, Wadi Siq, comes in from the high land in a south-of-west direction. The latter, which at its head is called Wadi Otha, heads in Gebel Abu Rumêl, and receives from the right Wadi Tayiba from the hills behind Um Saha, and opposite it on the other side, Wadi Abu Zarqa, from Gebel Koli; while further down nearer the mouth, Wadi Qên comes in from the right from Um Saha. Wadi Siq is a fairly open valley which rises somewhat rapidly towards its head, but does not seem to present any obstacle to its exploration. Some well-grown seyal trees were seen near its mouth. At the fork between Wadi Siq and Khrêta there is a spur of the dolerite ridge of Abu Mezeraq (father of blueness), Koli and Um Iswed which forms more or less vertical sides, especially towards the latter valley.

Wadi Khrêta. From its junction with Wadi Siq this valley rises rapidly towards the high lands to the south. To the east it is bounded by the steep-sided dolerite ridge of Gebel Koli, etc; while on the west it has the plateau called the Fersh Abu Loz, from which it receives Wadis Marzeqa and Main. Higher up it forks, the western branch taking the name of Wadi Murr, which in turn is replaced by that of Zeraiqia, which heads in Gebel Zeraiqia and Abu Shejera, while the other, preserving the name of Khrêta, bends off to the east and heads in Gebel Zahir.

Fersh Abu Loz. From the fork of Khrêta a winding path for donkeys and camels leads up to the plateau called the Fersh Abu Loz (the almond plateau). This extends for a good distance reaching to the foot of Giddet el Ela. On the top, 1,064 metres above the sea, were the withered remains of numerous plants, while many bushes of retem and a tarfa tree were found on it. During the rainy season the water evidently collects in

shallow pools on the surface and deposits its mud, and in a short time the place is covered with verdure. The Bedawin take up their goats, sheep, camels and donkeys, and camp there as long as the food lasts. To the south-east of Giddet el Ela is a pass, the Naqb Abu Loz, Naqb Abu Loz. between the Fersh and the drainage which joins Wadi Shiddiq. From the fork of Khrêta and Murr, down to a little below the junction of the former with Siq, a distance of 12 kilometres or so, the wadi fell 305 metres. Its bed offered a fairly good path and was well clothed with retem, which further down was replaced by seyal trees, they in their turn giving way to the "ilban," while near its mouth the tarfa tree held sway. There is thus a fairly well-defined zone-system to be noticed amongst the plants and trees of the wadis, this being observed in all the main valleys of the western side of the Peninsula of Sinai. This wadi is fairly well populated by Bedawin, a fairly numerous encampment being noticed at the mouth, another about half-way up, while a third was in Khrêta, at the foot of the Fersh Abu Loz. There is plenty of water to be found in the side wadis, and as there is also plenty of grazing, the people lead a very easy life, the men doing nothing except going out hunting or paying an occasional visit to El Tor or Suez.

Leaving the mouth of Wadi Meâr and turning south, the edge of Gebel Hagab and Wiqran is skirted, the mouth of Wadi Wiqran, which Gebel Wiqran  
Wadi Wiqran. drains these hills, being also passed. This is a very narrow, steep and rocky valley, which soon terminates in the hills behind.

The first wadi of importance after Meâr was that of Shiddiq (the Wadi Shiddiq. valley with the wide mouth). It is well named, as it has a very wide entrance, which rapidly narrows as the wadi is ascended. In the plain are several seyal trees. Going up the wadi is extremely difficult on account of the huge boulders strewn in its bed. Not far up several pools of water were found which were said to be perennial, water trickling out of the rock above them keeping them constantly supplied. Numerous plants were found in this valley in the vicinity of the water. Over the pools flitted brilliant-coloured dragon-flies, while from shady nooks under the rocks the beautiful maidenhair fern peeped out. Lasaf was also met with, as well as "hammad," the wild fig, while near the pools "habbak", one of the mint family, an infusion of which is used for dressing wounds, and "hazam," the wild mignonette, are met with. This wadi is not practicable for camels except for a little way. Higher up water and palms are said to exist.

Standing on a hill overlooking this wadi, the drainage area is seen to be more or less basin-shaped. On the north side the edge is formed

by the ridge of Wiqran and Giddet el Ela, while on the east the steep ridge, of which Gebel Shiddiq forms the lower peaks, and which culminates in the majestic crest of Um Shomer, forms the watershed, and its southern boundary is a long ridge running down from the latter hill.

About two thirds of the way up, the wadi forks, one branch going away northwards towards Naqb Abu Loz, while the other goes eastward to Gebel Um Shomer.

**Wadi Emlaha.** Leaving Wadi Shiddiq, several small drainages are passed in which are plenty of different plants such as bowal, rimth, etc., as well as a few seyal trees, and after travelling about 13 kilometres down the plain, the mouth of Wadi Emlaha is reached, which at its entrance is blocked with huge terraces through which the water has cut perpendicular-sided gullies. In addition to these terraces in the wadi itself, others also occur perched high up the sides of the hills, in some places filling up tributary valleys. At the mouth of the wadi there is a good well of water.

Wadi Emlaha is impracticable for camels for any distance up, on account of the small waterfalls of polished rock, which bar the way even for pedestrians. Higher up several good deep pools of water surrounded by bulrushes and other plants occur. The bed of the wadi being of loose sand, in which are many huge boulders, makes walking very fatiguing. The scenery up this valley is very fine, the wadi being only about 30 metres wide, and shut in by sheer cliffs of grey granite which rise between 200 and 300 metres above its bed. Looking up towards Gebel Um Shomer, from whence this wadi comes, a grand view of this fine hill is obtained. From the wadi it rises away in a sheer cliff, which eventually breaks up into a series of jagged peaks rising one behind the other, and culminating in the huge cubical crest which distinguishes that hill from this side.

From the mouth of Emlaha, a footpath practicable for camels goes up on to the low foothills, and leads into the higher reaches of the wadi.

The general aspect of the country is that of a high central range of peaks which culminates in that of Um Shomer, falling away to the north and south, while to the west the foothills gradually run down almost to the level of the plain. Leaving this wadi, the road led down the plain past the mouth of Isli which will be described by the other Survey party who went up it.

**Wadi Themelli** Three kilometres south of Isli the mouth of Wadi Themelli was crossed, which heads in the hill bearing the same name. It is little more than a gully, and is far too rough to ascend, but its course could be made out fairly well from the top of a hill which overlooks it.

About 3 kilometres farther south Wadi Abu Gorf was passed, so <sup>Wadi Abu Gorf.</sup> called because of the patches of sand and marl which are attached to its sides. This is, however, quite a characteristic of all the wadis in the region. On the right bank of this valley, and about 2 kilometres out in the plain, stands a very conspicuous two-peaked hill visible as far north as the Wadi Hebrân, called Qerain Utud (the horns of the kid) because <sup>Qerain Utud.</sup> it actually resembles in appearance the budding horns of a kid. This hill is the first of the outlying masses of granite, etc., which are met with further south in the coast plain.

Further on is Wadi Theman, a short, wide-mouthed valley which <sup>Wadi Theman.</sup> suddenly ended in a few narrow gullies heading in the neighbourhood of Gebel Theman. Near its head this wadi receives another, the Wadi Sifsaf. Beyond this valley there is a maze of isolated hills in the plain, the most important of which is called Gebel Um Rieh (the mother of wind). This hill takes its name from the small wadi which drains it, and heads in a hill bearing its name, one of a secondary range which lies at the foot of the one forming the watershed.

The next important valley is that of Wadi Um Hash, about 11 kilo- <sup>Wadi Um Hash.</sup> metres further south, which at its mouth is practically a plain, but narrows rapidly to about 200 metres. At its mouth it receives Wadi Um Rewas from the neighbourhood of Gebel Um Sidr. This wadi was full of "bsilla," and there were numerous Bedawin with large flocks of goats and sheep feeding in it. Going up it towards the watershed, it suddenly narrowed where it received Wadi Girgir. This wadi enters through a pass of red granite, and just above this a stream of water was met which disappeared in the sand. Further up numerous pools of water were met with, and several palms were also seen, while nearer the head the whole valley was filled with water from side to side which rendered ascent impossible. On the sides of the wadi were numerous terraces hanging high above the present bed, and these could be seen extending to the water-parting at the head of the valley, the highest of them being over 900 metres above sea-level.

From Gebel Um Shomer down to this point the same type of country has prevailed, viz., a high watershed range, with a secondary range at the foot of it. A peculiarity of the latter is that it forms in many cases a secondary water-parting, the drainage often passing north and south for some distance until it can find a way through to the plain. This would seem to suggest that this interruption is in all probability the work of a fault which has let down the foot-hills, and the line of fracture being one of weakness, it soon became the path of all the drainage from both ranges.

Beyond Wadi Um Hash these distinctive characters are lost, and the range becomes broken up into a group of separate hills or peaks.

Returning down Wadi Girgir a path was found running over a low ridge from Wadi Morit, a feeder of Um Hash, into Wadi Tihi. It was in it, while engaged in mapping on Gebel Tihi, that a Sinai thunderstorm was first experienced. From the hilltop big banks of black angry-looking clouds were seen rolling up the watershed, and it was hoped they would pass on, but suddenly a second mass was seen coming up the hills in a direct line with our station. Instruments were hastily stowed away, and a rush was made for a slightly overhanging rock more than half way down, which was reached just as the first peals of thunder were heard. Scarcely had we got ourselves safely stowed away, when the raincloud which had been seen travelling in our direction, was upon us. Rain and hail descended in sheets, and for a time the surrounding hills were blotted out as by a mist, while ever and anon the scene was lit up by a blinding flash of lightning followed by a deafening crash of thunder. Soon the sound of rushing water was heard, and each gully could be seen pouring down a white frothy mass into the main wadi, down which a stream of water carrying pieces of wood and other debris was seen rushing. The storm only lasted about a quarter of an hour, and it was evident that the centre had not passed over us, for our camp, only 3 or 4 kilometres farther on, escaped it entirely. What a really severe thunderstorm is like is described by Mr. Holland.\*

Wadi Rashid.

The next important wadi is that of Rashid, which at the mouth is over a kilometre wide, and higher up widens into a plain in which are many terraces. Into this from the right flows a small wadi—Abu Bir—while opposite it there enters Wadi Abu Tarfa, so named because of the tarfa trees growing in it. Above this the valley is full of boulders which make very bad going. Climbing Gebel Letih, a hill on the south side of the wadi and forming the watershed, a good view of the surrounding country was obtained. Away to the east, through a mass of detached hills, could be seen the Gulf of Aqaba, with Sherm Bay and Ras Mohammed stretching towards the south, while immediately below is the mass of low hills drained by Wadi Mokateb, Um Khashm, Um Gatih and Abu Markh. To the north a good view of Gebel Tihi and the course of drainage from it was also obtained, while below to the north-east stretched the Wadi Letih which falls into Aqaba. This wadi heads close to that of Wadi Morit.

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\* "Ordnance Survey of the Peninsula of Sinai," Part. I, p. 226, et seq.

Passing out of Wadi Rashid, in side valleys whose there is plenty of water, the way lay between an isolated mass of red granite—Gebel Hanasia—and Gebel Mokateb, part of the foot-hills of the watershed range. Lying well out into the plain is another mass of granite, Gebel Masraia, which is connected to the main mass by a series of outliers. After passing these, the hills take a sudden bend to the east where Wadi Abu Markh (in which trees of that name occur) comes down from Gebel Abu Markh. This wadi exemplifies the remarks made earlier about the lateral valleys which occur between the main range and the foot-hills.

Wadi Abu Markh.

Passing southward across the plain, the Wadis Sahara (valley of the sunstroke), from the hill of that name, and Mokat el Dhib were crossed, and then that of Um Malaqa was entered. At the point where it enters the plain this wadi passes through a fairly narrow gorge in granite, but above this it opens out into a small plain which is very rough and stony, from which it again narrows, as it nears its head in Gebel Um Malaqa. In this wadi occurs the last water until Bir Sherm is reached.

From this point the hills become much lower, the red granite which nearly always forms the highest hills suddenly coming to an end in Um Malaqa. The continuation of the watershed is Gebel At el Gharbi, which is a series of sharp peaks of dolerite, quartz-felsite and diorite, and is continued by Gebel Madsus and Tima, a jagged ridge which ends against a plateau of red granite sloping towards the Wadi Khashaba.

Gebel At el Gharbi, etc.

This range is drained by Wadi At el Gharbi which heads near the base of Gebel Um Malaqa. Between it and Wadi Um Malaqa there are no hills, the water being parted by a slight rise in the plain. This wadi is the first to show a southward tendency in its drainage, and this is much more accentuated in the last wadi to be described, viz., Wadi Khashaba. From the former a path leads over some low ridges of quartz-felsite into Khashaba.

Wadi At el Gharbi.

This wadi is a wide shallow valley between a low granite plateau on the east, and a sharp-peaked ridge of sheared and unsheared felsite. On either side are small deposits of sandstones, much current-bedded, in the mouths of all the small, narrow, steep-sided watercourses. This wadi runs practically south-east until near its mouth it strikes a hill of harder rock, which heads it off to the south, where it passes out to sea between the igneous rock and a small hill of coral reef.

Wadi Khashaba.

In this valley and Wadi At el Gharbi, there are a few well-grown seyal trees, especially in the former near where it enters the sea. In all the

wadis, bsilla was fairly abundant, and the camels were never in want of fodder.

At the mouth of Khashaba there is a large sand-dune which blocks the way to the headland of Mohammed, the only path being along the beach for several kilometres.

The following conclusions may now be drawn from what has been already written.

1. That the peculiar lateral drainage noticed between the main range and the foot-hills is the direct result of an earth movement.

2. That, in general, the direction of the wadis is from north-east to south-west; the only marked exceptions to the rule are those of Wadi Solaf and El Sheikh, they flowing in a north-westerly direction.

3. The sudden break in the mountain mass between the Gebel Musa massif and Serbal is directly due to the geology, the rock present tending to weather easily and form plains.

4. The plain of Debbet el Ramli has been formed by the scour of the north-west wind acting on the sandstones and removing them, thus at the same time giving rise to the escarpment of El Ti.

5. The plain of El Qa, with the limestone plateau, is the result of a large fracture which has let down the ground to the west.

6. The enclosed valley of El Araba, with the parallel ridges, owe their origin to the differential weathering of the soft Nubian sandstone, and to the alternation of marls and limestones in the series.

7. It is probable that the general direction of the wadis has been determined by lines of fold or fracture since the general trend of the dykes is in a north-east-south-west line.

#### 4. METEOROLOGY.

Up to the 6th November there was a decreasing temperature, then a rise with sudden fall followed again by a rise which continued to the end of the month. During December there was a steadily falling temperature which culminated in the first week of January, 1899, in a severe frost for about a week, the lowest temperature occurring on the 4th. From this date there was another gradual rise, a maximum being reached on the 4th of February, followed by a rapid fall on the 7th, this being followed by another rise and corresponding drop to freezing point on the 21st. From this date until the 20th March the temperature was equable, a sudden fall taking place on this day followed by a steady rise to the end of the month.

During the five and a half months occupied by the survey rain fell on twenty days, on eight of which it rained heavily, and one day snow fell. Hoar-frost was seen on six different days. During the months of October and November thunderstorms were very frequent, while in the following March they were again prevalent.

There were thirty-five cloudy days, while during several others the sky was overcast for a time. Wind was prevalent along the coast during the month of December; but at the end of February and during March there were frequent gales and sandstorms. The prevalent wind is north or north-west, but in the early part of the year strong south-east winds, very hot and unpleasant, were experienced, similar to those met with in the Nile valley. On the sea-coast a strong north-west wind usually blows every day.

On the other hand when a south-west wind blows it generally brings rain.

## 5. NATURAL HISTORY NOTES.

As the botany of the Peninsula of Sinai has been very thoroughly done by Dr. G. Schweinfurth and others it is not intended to enter into a detailed account of the different plants met with, many of which were collected and dried, being afterwards named for me by the courtesy of the former. It is enough to indicate the places where the plants were most abundant. In the wadis to the east and south of El Tor many plants are found wherever a water-pool or trickling stream is met with; but the places par excellence where flowers are in most abundance are the wadis draining the high-lying plain of Debbet el Ramli and Gebel el Ti. In these, plants are met with in abundance, clothing the wadis and sides of the hills with a many-coloured carpet which looks all the more refreshing if one has just left the barren coast-plain. But the thing which especially arrested my attention, and which has not to my knowledge been previously noted, is the well-marked zones into which the main trees and bushes divide themselves, these being determined by altitude above sea-level. Thus, speaking generally, the seyal and tarfa trees are not found above 427 metres above the sea, while next in order comes the "ilban" (Towara) "yessar" (Maazi) "moina" (Ababda), which gives place to the retem at 722 metres, the latter persisting up to the watershed. This statement of levels means that the last tree of the kind under consideration has disappeared, but there is a certain altitude common to any two for a certain distance.

It must be pointed out however that it seems possible, where the conditions of soil and plant-food are favourable, for plants to exist far above their usual altitude, this being seen in the tarfa groves in Wadi el Sheikh and El Gharbi, where the soil was a rich-looking marl.

Animals.

Passing to the animals, amongst the mammals, the ibex is the most common, being seen several times in numbers from two to ten together. Gazelle were only seen once or twice and seem to be much less common than the ibex. Leopards occur all over the high plateau and though none were actually observed, yet fresh tracks were met with several times and one was seen by the Bedawin approaching the camp in Wadi Sheqer. They are much hated by the Bedawin on account of the loss in camels caused by them each year. The day previous to that in which the camp was pitched in Wadi Sheqer, a camel was killed by a leopard quite close to the camp. Wolves and hyenas are also found in the sedimentary area. Hares were frequently started in the wadis round the Debbet el Ramli, on the northern half of the peninsula, but none were seen in the south.

Hyrax also occur in different wadis. Snakes were very rarely seen during the period spent in the country; whether it was due to the cold weather, or only because they were few in number is difficult to say. Only one *Cerastes* was seen and killed at Ras Mohammed, the others were of a harmless variety.

Numerous eagles abound in the hills, as many as forty were seen sitting on a small hill near the camel which was killed by the leopard in Wadi Sheqer, one of which having been killed was found to have a stretch of wing of 2·5 metres.

Ravens were fairly common. Peregrine falcons also were seen in the cliffs bordering the Debbet el Ramli. Two kinds of partridges were seen frequently in the northern half of the peninsula; these have been described and figured in the Report of the Ordnance Survey of Sinai Pt. I.

Numerous chats were also met with in all the wadis, as well as many wagtails.

Water Supply.

Except in the coast-plain between Suez and Wadi Gharandel, and the range of El Araba and Qa plain, water-supply need cause no anxiety to the traveller. In the main hill-mass water occurs in nearly every main wadi as well as in many of the side ones. In all the big mountain masses like Serbal and the Sinai massif water occurs in many rock-pools (often of large) size which are available all the year round, but in many of the wadis there are running streams, e.g. Wadi Geba, Wadi

Etla, etc. In the igneous ranges the water is good except where it rises from the bed of the wadi when it is often brackish and unpleasant-tasted. In the sedimentary area the water is often of a distinctly saline nature, in some places, as at Wadi Tayiba and Ethâl, being extremely brackish and unfit for drinking. In Wadi Gharandel the water is very evil-smelling and bad-tasted in spring, but said to be sweeter in winter. There is a plentiful supply of water here.

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## PART II.

### GEOLOGY.

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INTRODUCTION.—In dealing with this part of the memoir, it is necessary to notice the previous work done on the district under description, giving the conclusion arrived at by the various authors, and discussing and comparing their results as they coincide or diverge from those to which the writer has been led.

This district has been visited by several well-known geologists, e.g., Russeger, Fraas, Rothpletz, Bauerman and Le Neve Foster, Holland, Hull, Walther and Blanckenhorn, all of whom have published their conclusions. It is to Walther that geologists are indebted for the largest amount of individual work, and the most complete map hitherto published. Although not agreeing with all his deductions, it is impossible not to admire the way in which he did his work in the limited time at his disposal.

It is to Bauerman that the credit of the discovery of the Miocene and the faulting of the Carboniferous in Wadi Nasb is due. In the working out of the Miocene his work has been supplemented by Rothpletz and Blanckenhorn.

Russeger was the first to attempt a detailed account of the rocks, and though he made some mistakes as to the relations of the Eocene and Cretaceous rocks, they were quite allowable in the state of geological knowledge then existing.

In this memoir the geology is described under the following divisions:—

- SECTION I.—Recent and Pleistocene deposits.
- „ II.—Pliocene and Miocene beds consisting of conglomerates, gritty limestones, and gypsum.
- „ III.—Eocene.
  - (a) Upper or Bartonian.
  - (b) Middle or Parisian.
  - (c) Lower or Suessonian.
- „ IV.—Cretaceous limestone and shales.
- „ V.—Nubian Sandstone.
- „ VI.—Carboniferous.
  - (a) Sandstone.
  - (b) Limestone.

SECTION. VII.—Faults and Folds.

„ VIII.—Igneous and Metamorphic Rocks.

(I) Igneous Rocks.

1. Granites.
2. Syenites and Diorites.
3. Dykes and Veins.
4. Lava Flows.
5. Volcanic Necks.

(II) Metamorphic Rocks.

1. Gneisses and Schists.
2. Garnetiferous Schists and altered Sandstone.

„ IX.—Economic geology.

„ X.—Denudation and Weathering.

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SECTION I.—RECENT AND PLEISTOCENE.

*Plain of Qâ.*—In describing the deposits in this plain, and the wadis which flow into and across it, it is convenient to divide it into two parts (a northern and southern), the imaginary boundary between these being a line joining El Tor and the mouth of Wadi Shiddiq.

Taking the southern half first, the deposits can be divided into two fairly distinct groups, the eastern one being of fluvial and partly of lacustrine or marine origin, while the other is entirely marine.

The eastern part, opposite the mouth of Wadi Shiddiq in the middle of the plain, is composed of sandy clays, evidently lacustrine or fluvial, and derived in all probability from the disintegration of the Cretaceous Marls higher up, beneath which comes the marly limestone of marine origin which forms the floor of El Wadi. Nearer the hills this sandy clay gives place to sand and gravel, which gradually becomes coarser until it is a mass of granite and other igneous boulders mixed with blown sand.

Wadi Shiddiq. At the mouth of Wadi Shiddiq large mounds or gors of granite boulders occur, while further up the valley, and perched on its flanks, are patches of sand and gravel often presenting vertical sides. In the floor of the wadi itself there is a layer of these gravels which is bound together into a conglomerate by a calcareous cement.

Wadi Emlaha. Along the flanks of the hills are mounds of consolidated sand, evidently part of the same series. At the mouth of Wadi Emlaha large masses of gravel and boulders are piled up, through which the water has carved a path with vertical sides, which are now about 20 metres

high. On the flanks of the hills forming the wadi walls, masses of sand and igneous gravel are seen perched on either side as much as 31 metres above the bed of the valley. These in all cases exhibit fairly distinct bedding, and almost vertical sides, and suggest the idea that they have been deposited in the valley during a period of subsidence, the water afterwards cutting its path through them and the underlying rock as the land again rose. Higher up the valley, patches of a gritty sandstone composed of pieces of felspar, granite boulders, etc., are seen attached to the sides of the wadi between 30 and 40 metres above its present bed.

To the north of the wadi, higher up amongst the hills and about 4 kilometres from its mouth, a patch of this same sandstone, false-bedded, bent in various directions, and dipping east and west at angles varying between  $5^{\circ}$  and  $8^{\circ}$ , is found filling up an old valley. At one place where its escarpment was free from sand, it was found to be between 60 and 70 metres thick, and to be 689 metres above sea-level.

Further to the south, between Wadis Themelli and Theman, sand-rock was found capping the hills 424 metres above sea-level, while in the latter valley the same kind of sand and gravel patches were seen perched on its sides in the manner above described. Wadi Theman.

The next important valley—Wadi Um Hash—has big banks of bedded sand and gravel at its mouth, and similar patches stuck on its sides, through which the water has cut its way. Higher up, where it changes its name to that of Girgir, bedded masses of gravel and sandy clay are perched high on its sides, and continue right up to the watershed at an elevation of over 915 metres above the sea. Wadi Um Hash.

At the mouth of Wadi Rashid large banks of sand-rock also occur stretching down on either side into the plain, while the same is observed in the valleys of Um Malaqa and Ât el Gharbi, in all three wadis the sand-rock being found on their sides besides lying in the hollows of the hills. Wadi Rashid,  
Um Malaqa,  
Ât el Gharbi.

*The plain.*—At the point where the neck of Ras Mohammed widens out into the mainland a few small masses of coral-bearing limestone occur. Except for these the main mass of the plain is covered with igneous downwash from the wadis, now largely covered over with blown sand. No dunes occur, but the sand is distributed in small ripples which make walking very difficult.

*The western or sea-coast part.*—Starting from the neck of Ras Mohammed, where sand with fossil corals and shells occur, a flat expanse

of sand and sandy clay containing much salt, which has evidently risen very recently from the sea, as it contains shells similar to those found on the shore, begins where the former shades off into the plain. This, at first very narrow, rapidly widens out to about 2·5 kilometres, persisting at this width for about 7 kilometres when it is again restricted to a little over one. For 12·5 kilometres it continues like this, and then narrows down to a mere strip, the blown sand of the plain having encroached on it. After traversing about 13 kilometres more, it again widens out to about 2 kilometres, and continues of very irregular width, varying from a half to two kilometres for 20 kilometres further north from whence, until within 5 kilometres south of Gebèle, it maintains an average width of 1·5 kilometres, and then gradually dwindles to nothing at that village.

At the point mentioned as about 5 kilometres south of Gebèle a change comes over the plain deposits.\* Low mounds rise up from the edge of this saliferous clay, consisting of angular pieces of limestone and pieces of shells, suggesting in their appearance a "raised beach."

Qrum.

After passing over a sandy stretch of low ground lying at the foot of the low knolls to the east of Gebèle, about a kilometre to the south of the village of Qrum, a deposit of a granite sand bound together by salt and some carbonate of lime is reached, which contains numerous recent shells of every description, as well as some reef-building coral. This deposit is almost identical with that on the beach near Gharib Lighthouse, the fossils of which have been determined as Pleistocene at the Natural History Museum, London. It is this deposit that Walther marks as Miocene in the map which accompanies his "Korallenriffe der Halbinsel der Sinai." This is somewhat strange, seeing that the shells are the same as those on the shore, and the corals are also the same as those found in the sea close by. This deposit lies under the Quarantine Enclosure, and extends from the sea to a distance of 3 kilometres inland, while its northern boundary is a line due east of El Tor; in all it occupies an area of 9 square kilometres. To the east of El Tor this sand is full of different kinds of pelecypoda, but gastropoda are rare, while in places masses of coral occur. It is also present in a patch to the north-west of Tor close to the sea-shore.

\* Fourtau, in his paper on Western Sinai, gives a diagram-sketch of the beds which underlie the plain at Qrum. his knowledge being derived

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\* "Bulletin de la Société Khédiviale de Géographie," 1898. V<sup>e</sup> série, No. 1, pp. 19-20.

from various wells sunk in the vicinity. According to him, the following beds are met with in descending order :—

*Top.*

1. Granite sand.
2. Sandy, salt-bearing clay.
3. Sand with sub-fossil shells.
4. Corals.
5. Water-bearing sand.

From bed No. 3 the following shells and echinids were obtained :—

*Laganum Sinaiticum*, Fraas.  
*Clypeaster placunarius*, Agassiz.  
*Lucina lingua bovis*, Forsk.  
*Anomalocardia holoserica*, Reeves.  
*Cerithidea palustre*, Jousseau.  
*Asaphis violacens*, Forsk.  
*Dosinia amphidesmoides*, Reeves.  
*Trachycardium peregrinum*, Jousseau.

As all these shells are living in the Red Sea at the present day, the age of these beds must be late Pleistocene to Recent.

*The northern half of the plain.*—On the east side, to the north of Wadi Shiddiq, the plain from this point to the mouth of Wadi Geba is covered with granite, dolerite, and quartz-felsite boulders mixed with blown sand. Opposite the mouth of Wadi Meâr large mounds of these boulders are piled up, but they gradually thin out towards the middle of the plain where flint and limestone gravel take their place.

On the west, between El Tor and Gebel Saidna Musa, the ground is covered by a salty clay or sand over which are dotted many little mounds of sandy clay on which grows the shrub “ghargad.” Between Tor and El Wadi a saliferous clay occupies the low flat ground, which in winter is a marsh.

Along the seaward foot of this hill is laid a bank of gravel, etc., 15 to 30 metres thick, which is evidently of Pleistocene age, and is probably the continuation of the younger beach which runs along the foot of Gebel Hammam Musa, and which is described by Walther.

Gebel Abu Suwera.

*Top.*

Pure Coral Reef.....	3·5 m.
2. Fine breccia, in places covered by <i>Balanus</i> , echinid spines, <i>Ostrea</i> and coral fragments .....	1·5 m.
3. Base of coarse angular blocks of granitic material forming breccia containing blocks of sandstone, etc. .	1 m.
	<hr/> 6 m. <hr/>

Opposite the mouth of Wadi Hebran, but on the Araba side of the plain, small mounds appear near the foot of the ridge consisting of thin yellow sandstones,\* limestones, and marls containing *Turritella*, etc. These, with others shortly to be mentioned, are evidently the shallow water deposits which were laid down unconformably on the limestone which forms the flanks of Araba, after the rise of the land had set in. The dip in the range is  $12^{\circ}$ , but gradually falls to  $5^{\circ}$  out in the plain, where the marls disappear under the gravels.

Along the edge of the limestone plateau on the east nothing but mounds of flint, limestone, gravel and boulders are met with for some time, until the mouth of Wadi Themâm is reached. From this point there begins a series of mounds of gravel and marl which gradually occupy the plain. These show a great resemblance in appearance to the deposits in the Nile Valley, and have evidently been laid down under similar conditions.

It is remarkable that while in all the wadis to the south of Shiddiq, masses of sand-rock and gravel are found perched on their sides even up to the watershed, in the valleys to the north these are conspicuous by their absence. What the explanation is, is not at all clear, but the most likely solution of the problem is that a subsidence of the land must have taken place south of that point, sufficient to cover the hills, and that during that time the various valleys were silted up, the water again recutting its way through this silt and leaving patches sticking high up the sides of the valleys. These may possibly belong to the same period as the lake deposits to be described later in Wadis Ferân, El Sheikh and Solâf, which are known to be of freshwater origin, but search has hitherto failed to reveal any fossil in the former.

From what has been seen at various parts of Qâ it seems fairly certain that it is composed of the limestone which crops out here and there, although at present it is covered up by blown sand and downwash. At several places on the coast a hard limestone was seen to form the floor of the sea, and this passed away underneath the salty sand and clay which occupy the edge of the beach.

Although there is no direct proof in the lower part of the plain of its having been let down by a fault from a higher position, higher up there is, as will be shown later on.

These occur along the sides of Wadi Ferân and overlie those just described. They consist almost entirely of igneous pebbles, and the plain at the mouth of the above-mentioned wadi is also covered with them.

Younger  
Pebble Beds.

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\* See Section I.

In this valley these gravels and conglomerates occupy its sides and Wadi Sidri. bed for over 6 kilometres. They cap the low hills of gypseous marl which form the north side of the wadi, while the wide plain between this and the sea, as well as that of El Markhâ,\* are also covered with these beds and blown sand.

Seven and a half kilometres to the south of this valley there begins Wadi Wardân a deposit of gravel and conglomerate which in the sides of the wadi is seen to overlie a bed of white calcareous sandstone lying on the gypsumised beds to the east. From Wadi Wardân it sends off a long tongue to the north-west which lies on the gypsum the whole way until it ends against the (?) Pliocene of Gebel Raha, a distance of 11·5 kilometres.

To the west and north this deposit occupies the plain up to Ayun Musa, where it is replaced by the recent beach, but to the east of these springs it extends on to the Isthmus of Suez with the deposits of which it is continuous.

From the point where the above-mentioned tongue ends the (?) Pliocene forms a low plateau sloping west which is cut up by numerous wadis into long narrow tongue-like pieces on the ends of which the Pleistocene gravels are laid. This plateau continues for about 15 kilometres, when the Pleistocene sweeps round suddenly to the east and takes its place in a slightly lower plateau which occupies the ground from this point (the Wadi Kahali) from the cliff of El Raha on the east to the sea, and north on to the Isthmus of Suez. Here it consists mainly of sandy clay with some gypsum covered by flint conglomerate and gravel, and forming a plateau 15 to 20 kilometres wide from east to west.

Further to the west near the mouth of this wadi, patches of Beach Wadi Dehesi. Limestone occurred containing many pectens in a brittle state, as well as many bryozoa. Above this came a dark-green or brown clay full of salt which forms a crust on the surface. Thin beds of conglomerate formed the surface in the majority of places, while the clay formed a low plateau which extends up to Ayun Musa.

Round these springs there is a recent beach lying 15 to 20 metres Ayun Musa. above the sea. Some of the springs occur in low cones with a basin in the centre, which have evidently been formed by the water cementing the loose sand together by depositing the calcareous matter which it has in solution, as freshwater shells such as *Melania* were seen embedded in them. To the east of the wells was a bank of oysters which had not yet lost their colour, while numerous pieces of broken shells such as are seen on the coast were also observed in the sand.

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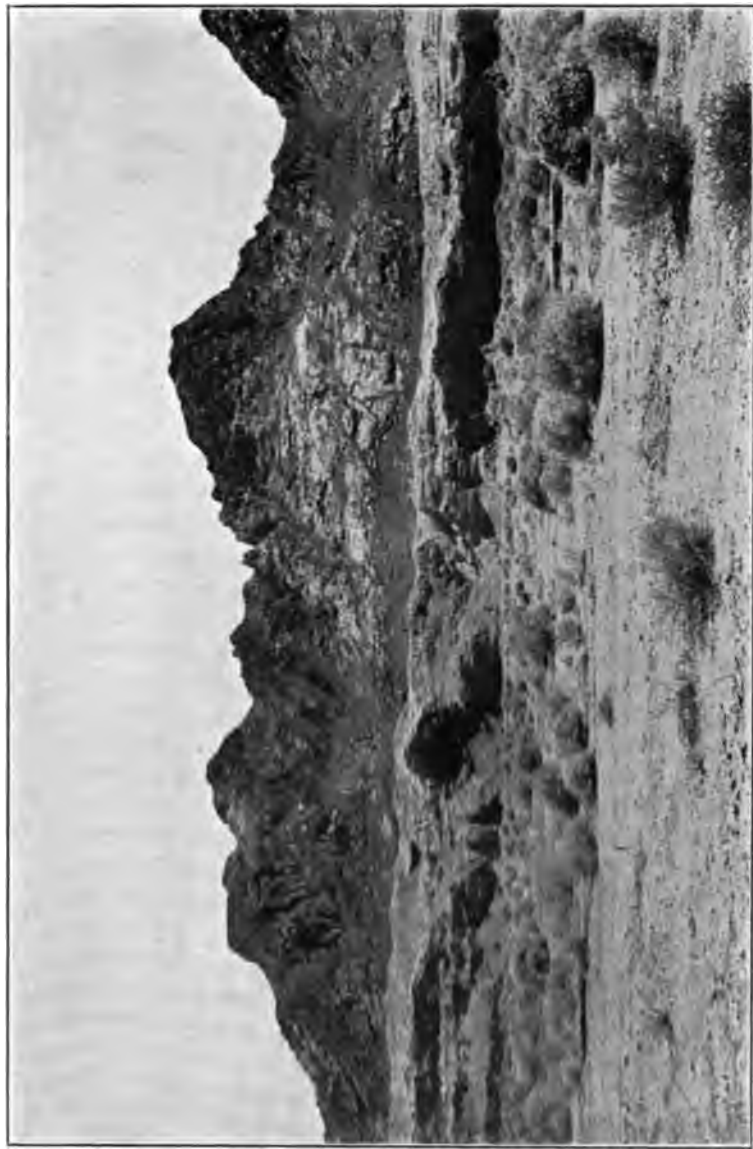
\* See Section VI.

*Therapsid and Insectivora*  
1. *Wadi Ghazal*  
2. *Wadi Ghazal*  
3. *Wadi Ghazal*  
4. *Wadi Ghazal*

1. *Wadi Ghazal*.—These deposits, consisting of bedded sandy clay and limestone, occur on either side near the Naph el Hara, and have the appearance of having been laid down in a lake. The presence of water-plants, tarfa and wadi at this spot is proof of good soil with no water in the bed of the wadi.

2. *Wadi el Ghazal*.—From the mouth of Wadi Qassab to El V on either side, and in the mouth of its tributaries, masses of bedded, sandy, marly, and in some places marly limestone, are found lying in the valley level up to about 30 metres above it, and their surface is to be seen on less horizontal, as it is highest above the valley down the wadi. In these occur small *Physa* or immature *Lymnaea*, and a mammalian tooth was also obtained from the low ground of Gebel el Ghurbi. In the wadi, a grove of tarfa with this disappears with the marly deposits. Further down, a junction with Wadi Nahr, where the road from Suez to the Convent crosses the wadi, the roots of water-plants, containing shells and numerous deposits again appear. This crosses about 2 kilometres from the mouth of Wadi Qassab.

3. *Wadi el Ghazal*.—About 1 kilometre above the mouth of Wadi Qassab these deposits again appear and continue to the



FRESHWATER LAKE DEPOSITS OF WADI EL SHEIKH.

To the east and north the greenish saliferous clay formed a low plateau capped by a bed of gravel and boulders which bent away to the north-east about half-way between the wells and the Suez Canal. On the shore-plain were many limestone boulders, while nearer the sea, and on the banks of the Canal, were recent marine beds full of shells, forming a raised beach which is evidently continuous with that between Suez and Gebel Ataqa.

#### FRESHWATER LAKE DEPOSITS.

These occur at four places :

1. Wadi Gharbi.
2. „ el Sheikh.
3. „ Ferân.
4. Foot of Gebel Hadûd.

1. *Wadi Gharbi*.—These deposits, consisting of bedded sandy clay and boulders, occur on either side near the Naqb el Hawa, and have the appearance of having been laid down in a lake. The presence of well-grown palms, tarfa and seyal at this spot is proof of good soil as well as water in the bed of the wadi.

2. *Wadi el Sheikh*.—From the mouth of Wadi Qassab to El Watia on either side, and in the mouths of its tributaries, masses of bedded sand, marl, and in some places marly limestone, are found lying from valley level up to about 30 metres above it, and their surface seems to be more or less horizontal, as it is highest above the valley lower down the wadi. In these occur small *Physa* or immature *Lymnæa* in abundance, and a mammalian tooth was also obtained from them. Towards El Watia these deposits spread on the one side to the plain of Elwi el Agramia, and on the other to the low ground at the foot of Gebel el Gharbi. In the wadi, a grove of tarfa with trunks of great thickness attests the presence of excellent soil in its bed, and this disappears with the marly deposits. Further down, a little below where the road from Suez to the Convent crosses the valley, these deposits again appear, containing shells and numerous remains of the roots of water-plants. This ceases about 2 kilometres above its junction with Wadi Solâf.

3. *Wadi Fêran*.—About a kilometre above the entrance of Wadi el Akhdar these deposits again appear and continue to the end of the



FRESHWATER LAKE DEPOSITS OF WADI EL SHEIKH.



marsh at the foot of the Oasis of Ferân, a distance of 7·5 kilometres. At first they are not much above valley level, but rise to 30 metres above it where the palm grove begins, being continuous with the bed of the wadi. On its western end there is no corresponding fall in level, and this can only be explained by supposing that the rock which stands in the middle of the valley was continuous with the sides and acted as the barrier to form the lake, it becoming breached eventually and the water gradually drained off.

A grove of tarfa and palms marks the site of this old lake, as it did in that of Wadi El Sheikh.

4. *Foot of Gebel Hadûd*.—In a hollow at the foot of Gebel Hadûd there occurs a small patch of sandy clay about 30 metres thick similar to that above described, through which the small wadis have cut their beds, thus proving that it existed before the drainage had been formed.

Walther had satisfied himself as to the freshwater origin of these marls during his journey in Sinai in 1887. No other explanation than their deposition in lakes formed by an interruption of the drainage seems to the author sufficient or capable of accounting properly for all observed facts.

## POST-TERTIARY FOSSILS OF WESTERN SINAI,

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

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### *Post-Pliocene.*

#### **Qrum and El Tor.**

*Haliotis cruenta*, Reeve.

*Capiluna Ruppelli*, (G. B. Sowerby).

do. do. var. *Barroni*, (R. B. Newton).

*Emarginula incisura*, A. Adams.

*Scutum unguis*, Linn.

*Clanculus pharaonicus*, Linn.

*Stomatella* sp.

*Turbo radiatus*, Gmelin.

*Nerita (crassilabrum*, E. A. Smith)= *Albicilla*, Linn.

*Hipponyx subrufus*, Lam.

*Cypraea erosa*, Linn.

do. *turdus*, Lam.

**Qrum and El Tor—(continued).**

- Natica (Mammilla) melanostoma*, Gmelin.  
*Cerithium caeruleum*, G. B. Sowerby.  
do. *Ruppelli*, Philippi.  
do. *erythreanense*, Lam. (= *tuberosum* Reeve).  
*Vertagus cedonulli*, G. B. Sowerby.  
*Pirenella mammillata*, Risso.  
*Triforis perlatus*, Issel.  
do. sp.  
*Vermetus*, sp.  
*Strombus fasciatus*, Born.  
do. *tricornis*, Lam.  
*Canarium dentatum*, (Linn) var. *erythrinum*, (Chemn).  
do. *gibberulum*, Linn.  
*Lampusia vilearis*, Lam.  
*Fasciolaria polygonoides*, Lam.  
*Melongena paradisiaca*, Reeve.  
*Vasum cornigerum*, Lam.  
*Mitra aureolata*, Swainson.  
*Columbella flava*, Bruguière.  
*Nassa pulla*, Linn.  
do. (*Alecton*) *glans*, Linn.  
*Murex ternispina*, Lam.  
*Chicoreus anguliferus*, Lam.  
*Sistrum elatum*, (Blainville).  
*Ricinula ricinus*, Linn.  
*Oliva inflata*, Lam.  
*Ancilla ovalis*, (G. B. Sowerby)=young of *A. cinnamomea*, Lam.  
*Terebra consobrina*, Deshayes.  
do. *duplicata*, Linn.  
do. sp.  
*Conus arenatus*, Lam.  
do. *erythraeensis*, Beck.  
do. sp.  
*Bulla ampulla*, Linn.  
*Dentalium octagonum*, Lam.  
*Arca imbricata*, Bruguière.  
do. *squamosa*, Lam.  
do. sp. (2 forms).  
*Anadara radiata*, (Reeve).  
*Barbatia lima*, (Reeve).  
*Limopsis* cf. *sordidus*, Tate.  
*Septifer bilocularis*, Linn.  
do. *excisus*, Wiegmann.  
*Spondylus aculeatus*, Chemn.  
*Lima* cf. *squamosa*, Lam.  
*Plicatula ramosa*, Lam.  
*Cardita calyculata*, Linn.

**Qrum and El Tor—(continued).**

- Codakia exasperata*, Reeve.  
do. *Fischeriana*, Issel.  
do. *fibula*, Reeve.  
*Divaricella ornata*, Reeve.  
*Arcopagia scobinata*, Linn.  
*Chione costellifera*, Adams and Reeve.  
*Circe corrugata*, Chemn.  
do. *pectinata*, Linn.  
*Tapes virginea*, Linn.  
*Chama Jukesi*, Reeve.  
do. *nivalis*, Reeve.  
*Orbicella Forskaliana*, Ed. and H.=(*O. mammosa*, Klunzinger).  
*Cyphastrea chalcidicum*, Forsk.  
*Prionastrea*, sp.  
*Goniastrea favus*, Forsk.  
*Metastrea Egyptorum*, Ed. and H.  
*Fungia patella*, Ellis and Solander, var. *lobulata*, Klunzinger.  
*Porites* cf. *incrustans*, DeFr.
- 

WEST SIDE OF RAS MOHAMMED AND PLAIN BETWEEN  
RAS MOHAMMED AND EL TOR.

- Capitula Ruppelli*, (G. B. Sowerby) var. *Barroni*, R. B. Newton.  
*Cerithium erythraeonense*, Lam. (= *tuberosum*, Reeve).  
*Vertagus cedonulli*, G. B. Sowerby.  
*Strombus tricornis*, Lam.  
*Dolium pomum*.  
*Oliva inflata*, Lam.  
*Terebra consobrina*, Deshayes.  
*Conus monachus*, Linn.  
*Dentalium octagonum*, Lam.  
*Arca imbricata*, Bruguière.  
*Anadara* sp.  
*Barbatia lima*, Reeve.  
*Glycymeris pectunculus*, Linn.  
*Margaritifera vulgaris*, Schumacher.  
*Ostrea* upper valve indet.  
*Cardita angisulcata*, Reeve.  
do. *calyculata*, Linn.  
*Codakia exasperata*, Reeve.  
*Arcopagia scobinata*, Linn.  
*Cardium leucostoma*, Born.  
do. cf. *maculosum*.  
*Chama nivalis*, Reeve.  
*Clypeaster placunarius*, Agassiz.

*Orbicella Forskaliana*, Ed. and H.  
*Prionastræa* sp.  
*Goniastræa favus*, Forsk.  
*Galaxea irregularis*, Ed. and H.  
*Cæloria Arabica*, Klunzinger.  
*Porites* cf. *incrustans*, DeFr.

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## SECTION II.—PLIOCENE AND MIOCENE.

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### PLIOCENE.

The presence of beds of undoubted Pliocene age on the west side of the Peninsula of Sinai, has hitherto been unknown to geologists. Even now, although the beds about to be described cannot be said to be entirely Pliocene, they, as shown by the fossils, constitute passage-beds between the middle Miocene and Pliocene. In determining some fossils which were sent to him recently, Dr. Blanckenhorn, of Berlin, pointed out that certain of them had Mediterranean characters and indicated a Pliocene age, while others associated with them were of Miocene age.

The following are the fossils from Wadi Amara which were named:—

*Clypeaster* n. sp. aff. *subplacunarius*, Fuchs.  
*Pecten cristatus*, Bronn.  
*Pecten revolutus*, Mich.  
*Pecten scabrellus*, Lam.=(*Sarmenticius*. Goldf.)  
extends from Tortonian to Pliocene.  
*Pecten* cf. *opercularis*.  
*Pecten Barroni*, n. sp. Blanck.  
*Pecten revolutus*, Mich.  
*Pecten. Schweinfurthi*, Blanck.

The following fossils also come from Gebel Zieti, which is near Wadi Amara :—

*Lucina* sp. aff. *incrassata*, Dub.  
*Lucina* div. sp.  
*Lucina columbella*, Lam.  
*Corbula*, sp.  
*Arca* sp.  
*Cardium* sp.

*Corbula revoluta*, Brocch.  
*Lithodomus*, sp. n. ?  
*Lithodomus* (*Botula*) cf. *cinnamomea*, Lam.  
*Cypræa* sp.  
*Natica redempta*, Mich.

Of these fossils Blanckenhorn writes as follows:—

“It is to be assumed that *Lithodomus* (*Botula*), *cinnamomea*, *Gastrochæna Retzi*, oysters of the *crassissima-gingensis* group, *Lucina* sp. aff. *tigrina* and corals like *Cyphastræa chalcidicum*, etc., persisted from Miocene to Pleistocene times in the Erythræan region in a salt “Binnen-see” situated somewhere in the deepest part of the Gulf of Suez. In the Upper Pliocene there was the second invasion of the Mediterranean forms into the Erythræan region. At this point there came in *Pecten varius*, *Pecten benedictus*, *Cerithium conicum*, *Ostrea cucullata* and *Plicatula*, *Arca lactea*, etc.

“Possibly in the neighbourhood of Sinai there may be a place which still contains remains of this more continental transition period between the Middle Miocene (Helvetian) and the Upper Pliocene.”

The deposit at Wadi Amara consists of:—

*Top.*—Limestone riddled with borings now filled with calcareous matter.

Below this came a yellowish sandy limestone containing gypsum and some veins of celestine while there were also numerous teeth of *Carcharodon megalodon* Ag., *pectens* and *echinids*. This rested on gypsum, as did the deposit on Gebel Zieti which is of a similar nature to that at Amara.

There are suggestions of the same order of things in the list of fossils recently determined by R. B. Newton, Natural History Museum, London, from Wadi Ethal, and Gebel Khadêd el Dhib. At Wadi Ethal there is a series of gravelly beds lying at the foot of the Usêt-Hammâm Farûn range, which contain many *Ostrea* and broken *pectens*. The former fossil has been determined as *Ostrea* cf. *undata*, which is a Mediterranean form, and is known from the Pliocene of Italy.

At the other place—Gebel Khadêd el Dhib—the following fossils have been determined by R. B. Newton and Dr. Blanckenhorn:—*Ostrea* cf. *undata*, *Pecten scabrellus* (?), Brocchi, *Pecten Josslingi* (?), G. B. Sow. and *Pecten* sp.; *Pecten Kochi*, Loc. = (*Pecten Fraasi*, Fuchs), *Pecten sub-Malvinæ*, Blanck., spines and plate of *Cidaris avenionensis*, Desm. Here again there is the suggestion of the admixture of 2nd and 3rd Mediterranean forms.

To the north of Wadi Wardan is a small group of hills consisting of re-made rock composed of pieces of limestone, marl and sandstone, all mixed indiscriminately, and further to the north covered by gravel, while their base is a calcareous sandstone resting on gypsum.

Between this patch and the cliff of El Ti there extends a low plateau which consists of gritty limestone at the top, calcareous sandstone in the middle, and gypseous marls resting on the gypsum bed. To the south this is seen to have a dip of  $10^{\circ}$  W., but further north the dip decreases to  $3^{\circ}$ . The plateau slopes upward and merges into Gebel el Ti, no cliff marking the boundary between the Eocene and this deposit. At the top is a more calcareous bed which may possibly contain foraminifera, while overlying this is a bed of rounded pebbles of a nummulitic rock and limestone boulders. This plateau covers an area of perhaps 15 by 4 kilometres, and further to the north is replaced by the Pleistocene clays and gravels.

These beds occupy the same position with regard to the gypsum as the Miocene or passage beds between the Upper Pliocene and Middle Miocene. Might they not represent the more continental transition period referred to by Blanckenhorn in the above-quoted remarks?

### MIocene.

Rocks of this age have been known to exist in Sinai for some time. In 1868, Bauerman,\* in a visit to Western Sinai for the purpose of examining the district for its old mines and ore deposits, described deposits from near the mouth of Wadi Gharandel, Wadi Tayiba, and Gebel Sarbût el Gamel, which he characterised as "Flint-Conglomerate with Corals." He also noted these beds in Gebel Abu Alaqa, and on either side of Wadi Sidri, where he describes them as being an alternation of flint-shingle with thin coral limestones and beds containing a coarsely ribbed *Pecten*. These he determined as Miocene.

In 1882 M. Raboisson† stated that he found Middle Miocene beds at Wadi Hawara and Gharandel from which he obtained *Ostrea Boblayei*, Deshayes.

In 1893 Rothpletz‡ described Miocene from Wadi Ethal northwards, the fauna of which he describes as North African.

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\* Q. J. G. S. 1869, p. 23, et seq.

† "Contrib. à l'histoire Stratig. de la Pénins. Sinaïtique," etc., 1883. Journal de l'Académie des Sciences de Paris, tome XCIV.

‡ "Stratigraphische von der Sinaihalbinsel"; Neues Jahrb. Miner. etc., 1893, Bd. I., pp. 101-104.

Miocene rocks can be shown to have a much greater extension in Western Sinai than was previously known before the present survey was made. They have been recognised all over the sedimentary area from the north side of Wadi Wardan to Gebèle, a small village south of the quarantine station at El Tor.

Beginning at the most southerly extension of the Miocene and going northward, the first deposit to be described is that outcropping near Gebèle.

Behind this village is a low escarpment which might have been the coastal scarp, and is covered with sand. It is composed of limestone weathering in a nodular manner and containing much salt and a bed of *Ostrea Virleti*. This disappears to the east and north under the sand and downwash from the hills, but evidently crops up again in some low knolls exposed to the east of El Tor,\* where the same oysters were again found, but, in addition, pieces of a flat echinoderm like *Scutella*, pectens, cardia and a few gastropoda were associated with them. Above this limestone came a bed of consolidated grit, unconformable to it, and then igneous gravel and sand. Here the beds seemed to dip sharply seawards. This limestone is exposed all the way round to El Wadi, the sides and floor of which it forms, and then it runs on to the flanks of Gebel Saidna Musa, being evidently of the same age as the bed capping that hill.

*El Saidna Musa and El Araba range, etc.*—The first of these hills consists of Nubian sandstone and Cretaceous marls, capped by a bed of crystalline limestone containing corals in very poor preservation. At its base and stretching a little distance inland is a raised beach laid on against the sandstone, while about half-way up the side of the hill occurs another. The following is the general sequence seen:—

*Top.*

1. Hard limestone dolomitised to a certain extent, containing corals from which all the septae have been dissolved. Its top is 233 metres above the sea. Dip 5° S.E. †
2. Pebble beds mixed with grit and containing fragments of shells.
3. Gritty rock with calcareous cement.
4. Yellow calcareous sandstone covered by a recent beach.

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\* See list of fossils at the end of chapter on Miocene.

† According to Walther this reef is a dolomite containing 40% of  $MgCO_3$ , and is of Pliocene age, but the evidence is all in favour of its being Miocene, as the beds to the north (of which it undoubtedly is an isolated part) are certainly Miocene, while those occurring in the plain and extending on to the flanks of Gebel Hammam Musa, have also been found to contain Miocene fossils. The probabilities are thus all in favour of a Miocene age being assigned to these beds. Further, no certain Pliocene beds have been met with in this region.

*Hot springs: their origin.*—At the foot of this hill issue several warm springs much resorted to by the Bedawin and the people of El Tor. The origin of these springs seems to be a line of fault running along the foot of the hill, up which the water from the plain of Qa, after sinking down through the porous beds which compose it, is forced by the hard face of the rock which has been let down. The appearance of the hill is in favour of the fault theory, as it ends in a more or less vertical face on a flat plain.

*Abu Suwêra.*—This bed of coral limestone caps the ridge from Saidna Musa to where Wadi Abu Suwêra has breached it, and is continued on the top of Gebel Abu Suwêra along to where Wadi el Araba cuts its way through it. At the foot of this hill is a small beach of crystalline limestone containing corals, which is about 13 metres thick. This is evidently part of the reef which has been faulted down from the hill top. The reef on the top of Abu Suwêra was in the same state of bad preservation as that on Saidna Musa, all the corals being much altered.

*Gebel el Araba and Qabeliat.*—Under these names are known the parallel ranges which extend from Gebel Naqûs to the Wadi Ferân, a distance of 54 or 55 kilometres.

Along the eastern and highest ridge from the mouth of the small drainage which comes down from the internal ranges opposite Naqûs there is a deposit of Miocene limestone and conglomerate on the side facing El Qa, which extends right up to Ferân. At its southern end it is covered largely with downwash, but as it is followed north it gradually crops out more and more, encroaching further up the dip slope of the ridge until it covers it entirely, forming the top of the escarpment. It overlies Cretaceous beds at the south end, but about a third of the distance northwards, Eocene beds in the form of *Nummulites Gizehensis* limestone, make their appearance under it, and continue up to Ferân.

*Unconformity.*—Between these older beds and this Miocene deposit there is a strong unconformity,\* marked by a bed of conglomerate which, where the Eocene beds occur, is made up of rolled pebbles of *Nummulites Gizehensis* limestone, and where the dips of the two series of beds could be measured, that of the older was 22°, the

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\* See Section I.

younger was  $15^{\circ}$ , to the east. It thus follows that as the dip-slope of the ridge was climbed, younger beds were observed near the plain, while at the top the older representatives were found forming the scarp.

*Faulting.*—About 30 kilometres from the southern end the beds are much broken and displaced by a combination of strike and dip-faults, by which the whole of the beds, including the younger, are broken into a series of secondary ridges† and shifted about 4 kilometres to the west, the younger beds capping the ridges in the vicinity of the fault. In addition the Miocene beds are broken by a strike-fault on either side of the Wadi Qabeliat, by which a secondary ridge enclosing a plain is formed to the east of the main escarpment.

The secondary ridges\* on the west side of the range, as has been stated previously, have been formed by a series of strike-faults, the throws of which have been determined, that of the most easterly is 104 metres, while the most westerly is 79 metres below it. In the western ridge there are the remains of a syncline, with its axis lying west of north and south of east, with dips towards the centre of  $8^{\circ}$  and  $10^{\circ}$  respectively. These observations prove that the age of these earth movements in question is Post-Miocene, probably Pliocene.

These Miocene deposits consist mainly of hard, more or less crystalline limestone, unconformably overlaid by the shallow-water representatives which were noticed in the plain of El Qâ earlier in this report.

The following is their sequence as made out from various exposures :-

*Top.*

1. A pecten bed † containing a flat echinid like *Scutella*, a few corals and a strongly beaked oyster. This ran under the white, sandy bed mentioned in the description of El Qâ.
2. Limestone full of pectens, etc., *Ostrea Virleti* near top.
3. Impure limestone in which pebbles of flint become very common. This contains a bed of *Ostrea Virleti*.
4. Hard brownish or grayish limestone containing a few corals in bad preservation.
5. A conglomerate of pebbles of flinty or nummulitic limestone.

On account of the scattered nature of the various beds, and of their never occurring together in the same escarpment, it is extremely difficult to obtain anything but an approximate thickness for them, but

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\* See Section I.

† See list of fossils at the end of the chapter.

there are at least 61 metres of them lying on the flanks of the main ridges of Araba, and they are about 488 metres above sea-level.

*Qabeliat*.—On the top of this escarpment there is a bed of these deposits 9 metres thick. This slopes down towards Wadi Ferân where the following section was obtained :—

*Top.*

1. Crystalline limestone containing small echinids and a thin layer of <i>Ostrea Virleti</i> ... ..	9 metres
2. Limestone with echinid spines ... ..	3 „
3. Limestone containing <i>Heterostegina depressa</i> , d'Orb... ..	3 „
4. Limestone containing a thick-shelled oyster like that found in El Araba, and large pectens ... ..	3 „
	<hr/>
	18 metres

The whole were dipping 8° to the east.

*Limestone plateau east of El Qâ*.—On this plateau occur outliers of Miocene deposits at three places, i.e., Gebel Asfar, the sides of Wadi Abura and Gebel Rigma and Wagraf. The first and last occupy the highest points of the plateau.

*Gebel Asfar*.—This hill, composed as it is almost entirely of Miocene deposits, seems to have been deposited in a syncline formed of Eocene and Cretaceous rocks, for although the opposite side of the basin is now removed, evidence is forthcoming of its existence higher up the Wadi Abura. On the remaining side it dips 30° to the north-east. The following is the sequence of these beds from above :—

*Top.*

1. Mass of calcareous sandstone.
2. *Heterostegina* bed with bits of *Pecten*,\* etc.
3. Calcareous grits containing coral.
4. An alternation of sandy and gritty beds with conglomerate.
5. Conglomerate of flints, flinty limestone and nummulitic limestone pebbles.

These beds dip at an angle of 5 degrees E. 5° S. It was impossible to measure the thickness of the different beds, because they formed steep precipices where well exposed, and where examined

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\* See list of fossils at end of chapter.

were covered with debris. On the sides of Wadi Abura deposits of the same brown colour and pebbly, gritty nature also occur.

*Gebel el Rigma.* \*—The beds here are again laid down in a sharp syncline of nummulitic limestone, and consist of similar sediments to those in Gebel Asfar. The following is the succession:—

*Top.*

1. Conglomerate of rounded flint pebbles, lying 850 metres above the sea.
2. Thick beds of gritty limestone alternating with conglomerate, and containing at the base corals and oysters.
3. Conglomerate of nummulitic limestone pebbles, containing a thin bed of gritty limestone in which occur pieces of an echinid (*Scutella*).

These outliers are evidently the remains of a much larger deposit which has been removed, the isolated patches owing their existence to their position. That they are older than the fault which separates the sedimentary area from the igneous ranges is undoubted, since the base of the deposits at Gebel Asfar has been let down below ground at the mouth of Wadi Geba.

*Wadi Khadahid.*—Near the mouth of this wadi the plain deposits are seen to be composed of marly beds lying on a calcareous sandstone, which is laid on the edge of nummulitic limestone containing *Nummulites Gizehensis*. The following is the sequence from above:—

*Top.*

1. Marl with veins of gypsum.
2. Clay.
3. Fine sandstone.
4. Gritty calcareous sandstone containing pectens.

The basal beds are tilted at an angle of  $30^{\circ}$  and rest on those of the nummulitic limestone, which dip  $60^{\circ}$  to the west. This seems to prove that the earth-movements were later than these beds, and it is very probable that when the fossils from them and the patches which rest on the top of the limestone hills to the east be examined, they will be shown to belong to the same deposit and that the former have reached their present lowly position through being let down by a fault. In the gravels which overlie the marls, igneous boulders occur, they having evidently come down Wadi Ferân at a later date.

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\* See Section II.

*Gebel Ekmi.*—On the west side of the camel-path leading to Wadi Ferân there is a different series of beds to those described above. The following is their sequence:—

*Top.*

1. Crystalline limestone containing corals 299 metres above the sea.
2. Sandstone.
3. A thin conglomerate.
4. Sandstone.

Borings of *pholadidæ* and pieces of shell like *Tridacna* are to be seen on the weathered surface. Here the beds were dipping from 10° to 12° to the west.

A little to the north of Gebel Ekmi, on the side of Wadi Ferân, these beds, dipping at 15°, rest on what appears to be Nubian sandstone, dipping 40° W.:—

*Top.*

1. A mass of conglomerate of flints and pebbles of nummulitic limestone.
2. Yellowish marls.
3. Calcareous limestone containing many oysters.
4. Thin limestone with coral.
5. (?) Nubian sandstone.

These beds extend right across the plain to Qabeliat, at the foot of which coral-bearing limestone lies on gypsum.

*North of Wadi Ferân.*—The deposits described to the south of this wadi are evidently continued to the north, and have their deep-water representatives in the large mass of fairly pure limestone which forms the low plateau between Wadi Withr and the ridge connecting Gebels Abu Alaqa and Mokateh. This plateau measures 19 kilometres average length, and 10 kilometres in width. Taking the exposures examined on the side of Ferân in their order from east to west, the following are the sections seen:—

*Wadi Khrêza.*

*Top.*

1. Calcareous beds containing *Ostrea Virleti*, Desh., pectens, etc.
2. Sandy limestone full of flat echinids *Amphiope* cf. *palpebrata*, Pomel.

These rest on the nummulitic limestone which here dips at 32° W., and in turn pass under the greenish marly beds mentioned in the description of El Qâ.

*Gebel Withr.*—In this section \* upper beds are present :—

*Top.*

1. Calcareous grit and sand containing corals, casts of pelecypoda and gastropoda, all badly preserved.
2. More calcareous beds with grit.
3. Greenish marls, reddish at the base, the whole deposit being 70 to 80 metres thick. These form the limb of a syncline, of which the previous section composed the other, the limestone having been removed in the latter.

In the *Gebel Withr* section, gypsum and gypseous marls, which were found to be altered Cretaceous beds, underlie the Miocene deposits. In the Miocene plateau the beds are mainly yellowish limestone containing sandgrains.

*Between Gebel Khadêd el Dhib and Withr.*—Near the mouth of Wadi Ferân, where a hill of nummulitic limestone forms its northern edge, there is a “Beach deposit” let down in a faulted syncline, which is evidently part of the deposits further to the east. It consists of the following beds :—

*Top.*

1. Conglomerate of limestone pebbles.
2. Gravel containing rolled nummulites.
3. Ochreous, calcareous grit with echinid spines, pectens, etc.†
4. A basal marly bed.

These beds dip  $15^{\circ}$  E., and on the edge of the fault  $30^{\circ}$  W., while the underlying nummulite beds dip  $30^{\circ}$  E.

Returning to the east side of the plateau, after leaving Wadi Ferân, the basal beds are not seen, as they have been let down by a fault against the Cretaceous marls. This fracture is continued along the foot of *Gebel Abu Alaqa*‡ which next falls to be described.

*Gebel Abu Alaqa.*—This hill is composed of Nubian sandstone at the base with some Cretaceous marls overlying it, above which come the Miocene deposits which are the same as those in *Gebel Wagraf* and *Asfar*, and are bent up into a small syncline.

On the west side of the fault the beds dip  $27^{\circ}$  W., while on the north side of the syncline (whose axis is east and west) the dip is  $22^{\circ}$  S., and on the opposite side it is only  $5^{\circ}$ .

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\* See Section II.

† See list of fossils at end of chapter.

‡ See Section III.

*Wadi Sidri*.—Passing down this wadi the sequence of the area can be fairly well seen :—

*Top.*

1. Fairly pure limestone which forms the main mass of the plateau.
2. Flint conglomerate (subangular) cemented by lime. (This is probably a reconstructed limestone).
3. Loose sandy and gritty beds.

There is a dip of  $25^{\circ}$  to the south-west on the edge of the area near the mouth of Wadi Budra, and current-bedding is well seen in the sandstones. There is also a slight dip eastward from Gebel Withr, but a more pronounced one to the south. There is evidently a roll north and south towards Wadi Sidri and Ferân.

From the beds seen in the eastern half of this deposit it would seem that the shore of the sea in which they were laid down was not far distant, and that the water deepened fairly rapidly to the west, the conglomerates which are a conspicuous feature in the eastern deposits not being met with on the west. Wherever the base of the Miocene is visible on the west it is seen to rest on a floor of gypsum and gypseous marl which stops short at a fault along Wadi Withr, the latter having thrown down the unaltered limestone against it ; the fracture is therefore subsequent to the overlying newer beds.

*Sêh Baba*.—To the north of this Wadi a small hill has yielded Eocene foraminifera of Libyan age, and this series has some things in common with it, although there are other features incompatible with its determination as Libyan, viz., the presence in it of pebbles of limestone containing *Nummulites Gizehensis*. The final determination of its age must await the description of the fossils collected from it. The following is the sequence observed in it :—

*Top.*

1. Crystalline beds with various fossils.\*
2. Limestone with large oysters.
3. Foraminiferal limestone.
4. Limestone with derived flints.
5. Marls.
6. False-bedded sandy limestone.
7. Gypseous marls with pectens, (?) *echinolampas*, etc.
8. Marls which weather in a spheroidal manner.
9. Marl beds with gypsum.
10. Conglomerate of flints and pebbles of limestone, among which were some containing *Nummulites Gizehensis*. Some rolled fossils, apparently derived, are also present.
11. Gypseous clays.

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\* See list of fossils at end of chapter.

This deposit\* lies in a hollow between Cretaceous limestones and marls. On the east it dips  $20^{\circ}$  west while the underlying Cretaceous marls are inclined  $63^{\circ}$  in the same direction. On its western edge the Cretaceous limestone is almost horizontal, and against its broken ends rests this younger deposit at an angle of  $5^{\circ}$ .

Another patch, evidently of the same nature, was seen in a hollow lying on Cretaceous marls about 2 kilometres west of El Markhâ, against which the Cretaceous limestone is let down by a fault.

*Sarbût el Gemel.*†—This is the next place where beds of Miocene deposits occur. This hill occurs on the north side of Wadi Hamr in the angle formed by its junction with Wadi Ibn Sakkar and occupies the downthrow side of the main fault which has let down the younger beds to the west. The Miocene beds rest in a syncline of Cretaceous limestone dipping at  $40^{\circ}$  to the west, but with a much smaller angle of dip to the east. The following is a section of the beds:—

*Top.*

1. Conglomerate of sub-angular and rounded flints cemented by calcareous sandy matter.
2. Boulder conglomerate of Cretaceous limestone and flint.
3. Limestone and flint pebbles.
4. Beds of conglomerate.
5. Marly limestone.

A few pectens were obtained, and the thick-shelled oyster which occurs in the other deposits was also seen, as well as a few badly-preserved corals.

There is an extension of this deposit on the south of the wadi, and patches also occur along the flanks of Gebel Abu Demat as far as Wadi Ethâl, down the sides of which occur some deposits of the same age.

*Wadi Tayiba.*‡—At the mouth of Wadi Tayiba§ there occurs a series of tilted beds with a bed of andesitic basalt, which apparently lies concordant with the beds above and below it. Blanckenhorn§ gives the following section of these beds, with which the writer agrees, the

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\* See Section VI.

† See Section V. Also see list of fossils at end of Chapter.

‡ See Section V. Also see list of fossils at end of chapter.

§ "Das Miocän"; Zeitschr. d. Deutsch. geol. Gesell., 1901, Heft I, Band 53, S 77.

former regarding them as belonging to the Lower and Middle Miocene:—

Top.

1. Greenish, brittle sandstone with marl and gypsum ...	15 metres
2. Flint conglomerate with small fragments of black flint and few rolled nummulites, alternating with greenish, finely-laminated, marly sandstone streaked with gypsum. Shells of <i>Ostrea</i> sp., <i>Pecten cristato-cristatus</i> , and <i>P.</i> sp. ... ..	20 „
3. Green, brittle, nodular, marly clay flecked with manganese ... ..	0.6 „
4. Mottled marly sandstone ... ..	0.5 „
5. Coarse conglomerate ... ..	0.5 „
6. Dark melaphyre-basalt with green zeolites passing into brown-red tuff ... ..	10.0 „
7. Black, finely granular sandstone which appears altered by contact with the basalt.. ... ..	1.2 „
8. Grey sandstone ... ..	0.5 „
9. Breccia of reddish and grey nummulitic limestone fragments ... ..	1.0 „
Total ... ..	<u>49.3 metres</u>

Under these Blanckenhorn found red laminated marly limestone with small *Nummulites*, cf. *variolaria*, etc... .. 10.0 metres

This the writer did not see, and accordingly mapped all the limestones below as belonging to the Senonian.

With the determination of the age of the beds underlying the basalt, the writer does not agree, and regards them as the extension of the Oligocene which occurs to the west of the Gulf of Suez.

In the middle of Wadi Ethal \* is found 10 metres of sometimes soft, sometimes hard, marly sandstone and limestone with veins of gypsum, which dips 28° N.W., and contains the following fossils:—

Rolled nummulites.

Numerous shells of *Pecten cristatocostatus*, Sacco, var. *Newtoni*, Blanckenhorn.

*Ostrea* sp.

*Ostrea Virleti*. Desh.

and further on, *Ficula condita*, Brogn.

*Neptunus granulatus*, Milne-Edw.

*Balanus* sp.

\* "Das Miocän," Zeitsch d. Deutsch. geol. Gesell., 1901, Heft 1, Band 53, s. 77.

Rothpletz also collected from the neighbourhood of Wadi Ethal and northwards the following fossils:—

*Psammechinus dubius*, Ag.

*Spatangus ocellatus*, DeFr. = *Muretia Fuchsi*, Oppenh., according to Blanckenhorn.

*Ostrea batillum*, May.

*Pecten Malrine*, Fuchs.

To the west of Gebel Krêr is a second ridge, Gebel Gushia, consisting of a hard calcareous sandstone containing layers of flint pebbles, and in which *Ostrea Virleti*, Desh., were seen, beneath which came gypseous marls, the whole dipping west 3°. Further west, near the flanks of the Usêt-Hammam Farûn range, are beds\* forming a syncline, with a dip towards the centre of 12°, and consisting of the following members:—

*Top.* Marly beds with gypsum.

*Base.* Sandy calcareous beds containing pectens and ostrea.

These beds may perhaps be the basal members of the Miocene, but it was impossible to verify this as they were covered up to the east, and the matter was further complicated by the gypsumisation of these rocks. As this was the apparent relationship it has been adopted, and the beds above-mentioned have been regarded as the same as the gypsumised rocks about to be described.†

On the north side of Wadi Gharandel in Gebel Hoshera there occurs a series of beds which are evidently a continuation of those of Gebel Gushia. In this hill the following beds were made out:—

*Top.*

1. Beach limestone containing nullipores, pieces of *Pecten*, and casts of *Conus*, etc.
2. Whitish marly limestone containing thick-shelled, ribbed oysters. (*Ostrea Virleti*, Desh., and *digitalina*, = var. *Rohlfsi*, Fuchs.)
3. Greyish marls with oysters and gasteropoda.

These rest unconformably on gypsumised beds, which are of Cenomanian age as determined by the fossils. Other two patches of similar rocks occur to the north of this, while on the continuation of the ridge two more good-sized areas of these beds were discovered later. Gebel Ziêti is capped by the same beds as those met with in Hoshera. In the plain of Amâra there occurs an area of shallow-water deposits, evidently lying in a syncline of the gypsum which here forms the

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\* See Section IV.

† Since writing the above, the ostrea found in these beds has been identified as *Ostrea cf. undata* which points to a higher horizon, viz.—a passage bed between Miocene and Pliocene.

floor. In a hill near the north edge of the plain and not far from the Suez road a different kind of deposit was met with. It consisted of : —

*Top.*

1. Limestone riddled with borings now filled with calcareous matter.
2. A yellowish sandy limestone containing gypsum, and here and there veins of celestine, while there also occurred numerous large shark's teeth, flat and heart-shaped echinids, nearly all broken, as well as numerous small specimens about the size of split peas. Numerous specimens of *pectinidae* and echinoderm spines were found.

Gebel Khalafa. This deposit rests on the gypsum, and extends away towards the sea, towards which deeper water conditions seem to have existed, as there is a fairly pure white limestone in the series containing casts of the corals which were seen in the other localities, as well as the pectens. Further to the north this deposit contains, in the uppermost beds seen in the plain, numerous thick-shelled oysters (*Ostrea Virleti* Desh).

Higher up Wadi Wardân another patch similar to that at Ziêti was found capping a hill of gypsum. The top consisted of hard Beach limestone similar to that on the west side of the Gulf of Suez, in which several specimens of coral occurred, while the base was of a sandy nature and contained marly beds in which a few oysters were found, the whole being 122 metres thick. This was evidently part of what was once a continuous ridge, but which has been broken up into isolated outliers such as Gebel Khalafâ, Ziêti, and Hoshêrâ. Further to the north-east there is another patch of the same rock also lying on gypsum which is evidently continuous with the other exposures to the south.

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#### LIST OF MIOCENE FOSSILS

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

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##### Wadi Amara and Gebel Amara.

- Carcharodon megalodon*, Agass.
- Ostrea Virleti*, Desh.
- Pecten cristatus*, Bronn.
- Pecten revolutus*, Mich.
- Pecten scabrellus*, Lam.
- Pecten* cf. *opercularis*.
- Pecten Barroni*, n. sp. Blanck.
- Pecten Schweinfurthi*. Blanck.
- Schizaster* sp.
- Schizaster* cf. *Parkinsoni*.
- Clypeaster subplacunarius*, Fuchs.
- Echinocyamus* cf. *Studer*, Sism.

**Gebel Zieti.**

*Lucina* sp. aff. *incrassata*, Dub.  
*Lucina* div. sp.  
*Lucina columbella*, Lam.  
*Corbula* sp.  
*Arca* sp.  
*Cardium* sp.  
*Corbula revoluta*, Brocch.  
*Lithodomus* n. sp. ?  
*Lithodomus* (*Botula*) cf. *cinnamomea*, Lam.  
*Cypræa* sp.  
*Natica redempta*, Mich.  
*Symphyllia* sp.

**Gebel Hoshera.**

*Carcharodon megalodon*, Ag.  
*Ostrea digitalina* var. *Rohlfsi*, Fuchs.  
*Ostrea* sp.  
*Ostrea Virleti*, Desh.

**Seh Baba and Wadi Legam.**

*Ostrea digitalina*, Eichw.  
*Pecten cristatocostatus*, Sacco.  
*Gigantopecten latissimus*, Brocch.  
*Pecten* sp.  
*Pecten cristatus*, Bronn.  
*Serpula spirulæ*, Lam., (derived from Eocene).  
*Celopleurus* ?

**Gebel Sarbut el Gemal.**

*Ostrea* sp.  
*Pecten Ziziniæ*, Blanck.  
*Pecten revolutus*, Mich.  
*Pecten* sp.

**Gebel Withr.**

*Ostrea Virleti*, Desh.  
*Pecten Ziziniæ*, Blanck.  
*Pecten sub-Malvinæ*, Blanck.  
*Echinolampas amplus*, Fuchs.

**Gebel Khadêd el Dhib.**

*Ostrea* cf. *undata*.  
*Pecten* sp.  
*Pecten Kochi*, Loc.=(*Pecten Fraasi*, Fuchs).  
*Pecten sub-Malvinæ*, Blanck.  
*Pecten Josslingi* ? G. B. Sow.  
*Pecten scabrellus* ? Brocch.  
Spines of *Cidaris Avenionensis*, Desm.  
*Cellepora* sp.

**North side of Wadi Ferân.**

- Ostrea digitalina* var. *Rohlfsi*, Fuchs.
- Ostrea Virleti*, Desh.
- Pecten Ziziniæ*, Blanck.
- Pectunculus* sp.
- Lucina* sp. (of the group of *L. Tigrina*, L.).
- Lucina* sp.
- Natica* sp.
- Amphiope* cf. *palpebrata*, Pomel.
- Symphyllia* ? Cast.
- Heliastrea* ?
- Orbicella* sp.

**South side of Wadi Ferân,**

- Ostrea frondosa*, Serres, var. *caudata*, Münst.
- Ostrea Virleti*, Desh.
- Pecten* cf. *Beudanti*, Bast: not *P. Ziziniæ*, of Blanck.
- Pecten revolutus*, Mich.
- Pecten sub-Malvinæ*, Blanck.
- Solenastrea turonensis*, Mich.
- Operculina complanata*, Bast.
- Lithothamnium* sp.

**Gebel el Rigma and Wagraf.**

- Ostrea Virleti*, Desh.
- Solenastrea turonensis*, Mich,

**Gebel el Araba and Qabeliat.**

- Ostrea digitalina*, var. *Rohlfsi*, Fuchs.
- Ostrea Virleti*, Desh.
- Ostrea* sp.
- Pecten revolutus*, Mich.
- Pecten Ziziniæ*, Blanck.
- Pecten* cf. *Zitteli*, M.E.
- Pecten gloriæmaris*, Dub., var. *longolævis*, Sacco.
- Pecten sub-Malvinæ*, Blanck.
- Pecten cristatocostatus*, Sacco, var. *Newtoni*, Blanck.
- Spondylus*, sp.
- Corbis* sp.
- Cellepora* cf. *palmata*, Mich.
- Solenastrea turonensis*, Mich.
- Heliastrea* sp. nov ?
- Orbicella Schweinfurthi*, Felix sp.

**Wadi Khadâhid.**

- Pecten cristatocostatus*, Sacco, var. *Newtoni*, Blanck.
- Pecten sub-Malvinæ*, Blanck.
- Pecten Ziziniæ*, Blanck fragments.
- Pecten Kochi*, Loc.

**Wadi Geba and Gebel Asfar.**

*Ostrea digitalina*, var. *Rohlfsi*, Fuchs.

*Orbicella Schweinfurthi*, Felix sp.

*Operculina complanata*, Bast.

**Limestone north-east of El Tor.**

*Glycimeris pilosus*, Linn.

*Glycimeris*, probably sp. nov.

*Volsella Brocchi*, M. Eymar.

*Ostrea Virleti*, Desh. (S. E. of Gebéle).

*Pecten* cf. *opercularis*, Linn.

*Diplodonta* cf. *rotundata*, Montagu.

*Divaricella* cf. *ornata*, Agass.

*Tellina* sp.

*Callista erycina*, Linn.

*Papillicardium papillosum*, Poli.

*Solecurtus* cf. *strigilatus*, Linn.

*Kuplus* (*Septaria*) cf. *arenaria*, Lam.

*Solenastrea turonensis*, Mich.

*Heliastrea* sp.

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**SECTION III.—EOCENE.**

This formation has perhaps been less noticed by previous visitors to the Peninsula of Sinai than the Cretaceous, many of the rocks put down to the latter belonging in reality to it. Thus, in the map published by the Ordnance Survey of Sinai the southern part of the area is represented with fair correctness but in the northern part much that is Eocene is not shown. Similarly in Hull's map published with his memoir on Western Palestine, the whole of the southern part is shown as Eocene, whereas the main rock there is Cretaceous. Walther's map is on the whole the most correct published although he appears to be mistaken in putting as Eocene an area of Newer Tertiaries on the north of Wadi Ferân. Fourtau \* recognised no nummulitic rocks until the Wadi Ferân is reached, and his description of this area is largely based on that of Walther.

(a) *Upper or Bartonian.*

In the following account, it is endeavoured to divide this formation as far as possible, in the absence of fossil determinations for all the

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\* Op. cit.

Gebel Abiad. areas, into Upper, Middle, and Lower Eocene. Beginning with the Upper first, this division, as far as is at present known, occurs only in patches capping the range known as Gebel Abiad, lying to the north of Wadi Abu Qâda. On the point overlooking this wadi there were the following beds :—

*Top.*

1. Calcareous beds with hard layers in them; the softer laminæ contain *nummulites* and other *foraminifera*
2. Nodular beds containing derived nummulites.
3. Whitish limestone containing nodules of nummulitic rock, as well as *Operculina*, etc., thickness 15 metres.

This lay unconformably on the Gryphæa limestone of the Cretaceous. This deposit dips about 5° to the S.W. In another point of this range the white limestone bulked larger than in the first, but it also contained the rounded pebbles of nummulitic limestone and its thickness was about 90 metres, the same bed underlying it as in the first, while its dip was 5° N.E. To the east this bed lies against and upon the Cretaceous marl, and is faulted down against the Nubian sandstone at the foot of Gebel el Ti. Further north near the extreme end of Gebel Abiad at the head of Wadi Abiad (northern drainage of that name) the thickness of this deposit was found to be 116 metres; but the floor on which this deposit has been laid down is evidently very uneven, for, sometimes only 30 metres are seen, and in the case of the wadi close to the hill where the greatest thickness was found, only half that thickness was obtained. In Wadi Abiad the junction between this deposit and the underlying rock is very marked. The lowest bed consisted of rounded blocks of hard nummulitic limestone about the size of a man's head, with little or no matrix between, let into pockets like "potholes". The underlying bed contains nummulites, the Cretaceous bed having disappeared. In the hill where the greatest thickness was found, a bed full of blocks of foraminiferal limestone with a matrix of soft limestone was also seen.

From specimens from this area sent for determination to the Natural History Museum, London, Chapman \* has recognised the following foraminifera :—

*Globigerina bulloides*, d'Orb.  
*Operculina complanata*, (Def.) var. *discoidea*, Schwager.  
*Nummulites planulata*, Lam.  
*do. variolaria*, Lam.  
*Orbitoides dispansa*, Sowerby.

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\* Geol. Mag. Dec. IV. Vol. VII, 1900, pp. 308-316, and 367-373.

From these Chapman concludes that this deposit belongs to the Bartonian or Upper Eocene. Blanckenhorn \* has criticised this adversely and refers the deposit to the Miocene, but the writer is unable to agree with him in this view, as the field evidence is all in favour of its being Upper Eocene, the strong unconformity representing the break between the Middle division and this.

The strongest argument in favour of the present determination lies in the absence of pectens, echinids, and ostrea, all of which are present in abundance in the other undoubted Miocene deposits met with in this area. This point was kept in mind by the writer while examining the beds, and a careful search was made for other fossils with negative results.

(b) *Middle or Parisian.*

Coming now to the Middle Eocene, it forms the cliff of Gebel el Ti from where it bends away eastward opposite Suez, through Gebel Raha, Sudr, and Sin Bisher, a little south of which it descends into the plain running as far south as Gebel Abiad where it passes under the Bartonian; it emerges again further west and forms Gebel Um Adam and Sanâfa, its southern limit being almost on Wadi Gharandel. It contains *Nummulites Gizehensis* in the cliffs of Gebel Raha, while further south it is full of smaller nummulites and small foraminifera. No pelecypoda were seen at any point where it was examined, it being in general, a white chalky limestone.

The next place where these beds occur is in the range of Hammâm <sup>Gebel Hammâm Farûn and Usêt.</sup> Farûn and Usêt, † where there is a great thickness of nummulitic rocks, containing similar foraminifera to those found in Gebel Krêr. This range presents a steep escarpment to the sea, the dip at this point being practically nil, but when examined a little further to the east it is inclined at an angle of 10° thus showing that there is here a broken saddle the western limb of which has sunk under the sea. In this range the boundary between the Eocene and Cretaceous rocks has not been seen to the south but it undoubtedly occurs near the walls of Wadi Ethal. On the east of the sedimentary area and dipping west at angles varying between 8° and 30° occurs another patch of Eocene rocks forming the range of Gebel Krêr. † In this range the Eocene has <sup>Gebel Krêr.</sup> been thrown down to the east against the Cretaceous marls, while a

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\* Zeitsch. d. Deutsch. Geol. Gesell., 1900, pp. 417-418, 1901, pp. 75-79.

† See Section IV.

duplicate ridge of the former is formed further west. Further to the north, although the fault is continued, the throw is not sufficient to expose the marls and the two ridges become one. In this ridge is a series of limestones crowded with foraminifera, samples of which have been examined by Chapman \* who recognises the following genera and species of foraminifera :—

- Bolivina punctata* ? d'Orb.
- Globigerina bulloides*, d'Orb.
- do. *conglobata*, Brady.
- do. *cretacea* ? d'Orb.
- Discorbina rugosa*, d'Orb.
- do. *globularis*, d'Orb.
- Rotalia calcaliformis*, Schwager.
- Nummulites subdiscorbina*, De la Harpe.
- Nummulites curvispira*, Meneghini.
- do. *Gizehensis*, Ehr., var. *Pachoi*, De la Harpe.
- Orbitoides dispersa*, Sow.
- do. *ephippium*, (Schlotheim).
- do. *papyracea*, Boubée.

Ridge between  
Gebel Abu  
Alaqa and  
Mokateb.

From specimens collected underneath this horizon it was found that this ridge was composed of both Middle and Lower Eocene. For the general relations of the beds in this area see Section IV. After this locality no more Middle Eocene is found until the ridge between Gebel Abu Alaqa and Gebel Mokateb is reached where a rock crowded with *N. Gizehensis* and a smaller species is found underlying the Miocene deposits. This overlies the Cretaceous and sweeping round its flank crosses Wadi Ferân and extends down as far as Wadi Khadâhid, being inclined at angles varying between 32°, 60°, and 80°. At Wadi Khadâhid this bed contained numerous oysters and echinoderms, while at the base of the limestone were several fish-teeth. In a sample from this place Chapman\* has recognised the following foraminifera :—

Wadi  
Khadâhid.

- Truncatulina umbonifera*, Schwager.
- Nummulites gizehensis*, var. *Pachoi*, De la Harpe.
- do. *curvispira*, Meneghini.
- do. *Barroni*, sp. nov., (Chapman).
- do. *Ramondi* ? Defrance.

Gebel El  
Rigma.

At the top of Gebel el Rigma † these beds are found underlying the Miocene Deposit. They have been let down by a fault against the

\* Loc. cit.

† See Section. II.

Cretaceous marls. To the east of this beyond the cliff, the Eocene beds have again been let down by a fault against the *Gryphæa* bed of the Cretaceous, and are inclined towards the cliff at an angle of 30°. The beds at this place are full of echinoderms and oysters; of the latter the following have been determined:

*Ostrea rarilamella*, Desh.

*Ostrea Clot-Beyi*.

*Ostrea Fraasi*, M.E. = *O. elegans*, var. *exogyroides*, Oppenh.

To the south-east of this point these beds form the surface of the plateau resting against the gneiss and igneous rocks of the Central range; their characters are very constant all through except that here they contain thin beds of nodular limestone. Where this area was examined it was dipping at 30° to the east. Further west, near the mouth of Wadi Thaghadi, nummulitic limestone occurs on the top of the plateau overlooking this valley and faulted down against the Nubian sandstone. It also caps the hill on the east side of Wadi Abura, and underlies the Miocene deposits near its mouth. In Gebel Asfar this bed likewise underlies the Miocene deposits on one side at least, dipping steeply under them and apparently forming a sharp fold by which the older beds are made to appear on the east. It also appears in Gebel Safariat where it is dipping steeply at 55° towards the hills. (A section is given in the chapter on the Cretaceous, p. 134, in which the various beds of this formation are shewn). These beds are full of large nummulites, oysters, and the gasteropod *Thersitea* while a few corals were also found. \* Amongst the large nummulites Chapman † recognised the following species.

*Nummulites gizehensis*, (Forskal), var. *Ehrenbergi*, De la Harpe.

„ „ var. *Lyelli*, d'Archiac and Haim.

„ „ var. *Pachoi*, De la Harpe.

On the west side of the sedimentary area near the sea-coast at the mouth of Wadi Ferân is a small hill called Khadêd el Dhib where this rock occurs. It is the same as is met with on the east, and has been thrown down by a fault hading west, the beds themselves dipping west at 30°. Along the shore side of Qabeliat a small patch of this rock has been thrown down against the Cretaceous marls.

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\* See list of fossils at end of chapter.

† Loc. cit.

Gebel el Araba. In Gebel el Araba, however, this bed is continuous for a long way under the Miocene deposits. In Wadi Qabeliât, where the Miocene deposits have been faulted, the nummulitic bed is found immediately underneath. Higher up the cliff this bed is again found forming a small platform at the foot of the next patch of Newer Tertiaries which is faulted down from the main cliff. It also occurs in the main cliff in the same position as in the others. (For the general relations of these beds see Section I.) Here the dip was about  $22^{\circ}$  while that of the overlying Miocene was  $12^{\circ}$ . The nummulitic bed does not extend the whole length of the ridge of El Araba, as it was absent about 22 kilometres further south. Between it and the overlying deposit there is a bed of conglomerate composed of pebbles of nummulitic limestone.

(c) *Lower Eocene.*

There now remains to be described the occurrences of the Lower Eocene or Libyan series. There are only three known places where it occurs at present, viz. Gebel Krêr, \* a small hill at the confluence of Wadis Baba and Shellâl, and in Gebel Safariat. In the first of these places these beds occur between the Middle Eocene and the Cretaceous. In a specimen from this place Chapman † recognised the following foraminifera:—

*Miliolina circularis*, Born.

*Alveolina bosci*, Defr.

„ *decipiens*, Schwager.

*Bigenerina* (?) *nodosaria*, d'Orb.

*Globigerina Cretacea* ? d'Orb.

*Operculina complanata*. Defr. var. *canaliculata*, d'Arch.

*Nummulites Guettardi*, d'Arch. and Haime, var. *antiqua*, De la Harpe.

*Orbitoides dispansa*, Sow.

„ *papyracea*, Boubée.

Gebel Krêr. From these he concluded that these beds were of Libyan age. In the cliff of Krêr the thickness of Eocene limestone is at least 104 metres, but how much is Middle and what is Lower Eocene it is impossible to say without a careful examination. It is however certain that the Libyan beds form the smaller part of the cliff.

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\* See Section IV.

† Loc. cit.

At the junction of Wadis Shellâl and Baba, these beds form a small hill of which the following is a section :—

Junction of  
Wadis Baba  
and Shellâl.

Top.

1. Crystalline limestone with a bed of foraminifera at its base.
2. Gypseous marls containing *pectens* and *Echinolampas*, as well as layers of flints from the Cretaceous.
3. Beds of rounded and angular flints, lying unconformably on the Cretaceous.

In this rock Chapman \* recognised these fossils :—

*Textularia agglutinans*, d'Orb.

*Operculina complanata*, (Defr), var. *canaliculata*, d'Arch.

*Nummulites Ramondi*, Defr.

It is not known at present whether this one little hill is the whole of the Lower Eocene in this area, as the specimens from it are not yet determined.

One striking difference between the eastern and western shores of the Gulf of Suez is the absence of the Esna shales and the flinty limestone series so common on the Egyptian side. In no place have they been met with, and it would appear that while they were being deposited to the west, Sinai was a land surface undergoing denudation and degradation, the upper part of the Cretaceous being removed prior to the deposition of the Lower Eocene. In the northern half of the peninsula, denudation has been much more active, the whole of the Upper Cretaceous or Danian being absent, and nearly the whole of the 400 metres of the Senonian having likewise been carried away. From the general appearance of the rocks it would seem as though there had been a rapid subsidence, and the lower rocks were deposited in deep water, that after the Lower and Middle representatives had been laid down an elevation took place, (the most of the land having previously sunk beneath the sea as evidenced by the presence everywhere of Middle Eocene) during which there was a certain amount of denudation by which the unconformity seen in Gebel and Wadi Abiad was produced, while later a second subsidence took place to allow of the deposition of the Upper Eocene or Bartonian, the lower rocks being exposed so as to undergo degradation and furnish the pebbles and boulders seen in that deposit. Overlap must also have taken place as Bartonian beds are found on Cretaceous marls.

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\* Loc. Cit.

## EOCENE FOSSILS

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

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### Gebel Safariat.

- Odontaspis macrotus*, Agass. (Suessonian).  
*Turritella Boghosi*, Cossmann (    „    ).  
*Thersitea gracilis*, Coq. (    „    ).  
*Thersitea*, sp. nov.  
*Tectus*, cf. *ornatus*, Lam.  
*Scaphander* sp.  
*Ostrea Fraasi*, M.E. = *O. elegans* var. *exogyroides*, Oppenheim.  
*Carolia placunoides*, Cautraïne.  
*Meretrix* sp.  
*Callista suberycinoides*, Desh.  
*Echinolampas Crameri*, Loriol.  
*Heliastrea* sp.  
*Astrocoenia*.

### Gebel el Rigma and Wagraf.

- Ostrea rarilamella*, Desh.  
do. *Clot-Beyi*.  
*Ostrea Fraasi*, M.E. = *O. elegans* var. *exogyroides*, Oppenh.

### Gebel el Araba.

- Ostrea rarilamella*, Deshayes.  
*Carolia placunoides*, Cautraïne.  
*Spondylus Egyptiacus*, R.B. Newton.  
*Meretrix* sp.

### Wadi Khadahid.

- Ostrea* sp.  
do. *Reili*, Fraas; associated with *N.*  
*Gizehensis* and *N. curvispira*.  
*Ostrea Fraasi*, M.E. = *O. elegans* var. *exogyroides* (Oppenheim).

### Wadi Abu Qâda.

- Ostrea* sp.  
do. *Fraasi*, M.R. = *O. elegans* var. *exogyroides*, Oppenheim.  
*Plicatula polymorpha*, Bellardi.  
*Spondylus* ?  
*Bryozoa*.  
*Linthia* (basal fragment).

### Gebel Um Adam.

- Conoclypeus conoideus*, Lam.
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#### SECTION IV.—THE CRETACEOUS LIMESTONE AND SHALES.

These rocks occur all over the western side of Sinai from Gebel Saidna Musa on the south to Wadi Bagha on the north. They have been described more or less completely and with varying degrees of exactness by various writers. In 1866 the Rev. F.W. Holland, who was afterwards attached to the Ordnance Survey party deputed to make a survey of the country, with a view to elucidate some doubtful points in the journeying of the Israelites, visited the main areas and published a map geologically coloured shewing the boundaries of the different formations, but on account of the large area attempted in the time and the inability to visit sufficient points in order to fix boundaries he went widely from the mark in several places.

Bauerman \* in 1868 visited the district between Suez and the lower part of Wadi Ferân. His object apparently was to examine the old mining centres there; but he formed a very correct idea of the various formations in this district, much more so than some of the more recent observers.

From the hill at Naqb el Budra he obtained the following fossils which were named by the late P.M. Duncan, F.R.S.:

- Epiaster distinctus*, Agass.
- „ *tumidus*, Desor.
- Periaster oblongus*, d'Orb.
- Hemiaster Cenomanensis*, Cotteau.
- Physosoma Delamarrei*, Desor.
- Plicatula Fourneli*, H. Coquand.
- Pecten asper*, Lamb.
- Neithia alpina*, d'Orb.
- „ *tricostata*, Bayle sp.
- Exogyra plicata*, Goldfuss.
- Ostrea Auressensis*, H. Coquand.
- „ „ var. *major*. Duncan.
- † *Exogyra Overwegi*, Buch.
- Ostrea curvirostris*, Nielson.
- Radiolites* sp.

From Wadi Ferân he obtained the following fossils.

- Hemiaster Cenomanensis*, Cotteau.
- Ostrea Auressensis*, H. Coquand.

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\* Op. cit.

† This is probably *Exogyra Olisiponensis*, as *E. Overwegi* is not known below the Danian.

From Gebel el Ti the following were collected.

- Discoidea subuculus*, Klein.
- „ *Forgemolli*, H. Coquand.
- Periaster oblongus*, d'Orb.
- Hemiaster Cenomanensis*, Cotteau.
- Pseudodiadema variolare*, Brogn. sp.
- Exogyra plicata*, Goldfuss.
- Ostrea Auressensis*, H. Coquand.
- \* *Exogyra Overwegi*, Buch.

From these fossils and a study of those previously collected by the Rev. F. W. Holland, Duncan came to the conclusion that the most of the Cretaceous rocks belonged to the Cenomanian, but that there was also evidence to support the assertion that the Turonian as well as the Cenomanian was present. He based this view on the reported presence of *Hippurites* in the El Ti section examined by Dr. Le Neve Foster, and also the finding of some of these in Wadi Budra by Bauerman.

These *Hippurites* are however found too low in the series, as the writer has found the bed underlying others containing Cenomanian fossils. The *Hippurites* are in reality *Sphaerulites*, which occur in the Cenomanian.

In 1869 the Report of the Ordnance Survey of Sinai was published. This contains a chapter on the Geology of the Peninsula by the Rev. F.W. Holland,† to which is appended a list of fossils collected by the author, the Survey Officers, and others added on the authority of J. Salter. The fossils collected by the Survey are marked (\*) those by the Rev. F.W. Holland (H) and those added by Salter (S). They are arranged by localities.

#### 1. Gebel and Wadi Mokateb.

- \* *Strombus* cf. *mermeti*, Coq.
- \* *Turritella* sp.
- \* *Astarte pumica*, Coq.
- \* „ *obrutus*, Conrad.
- \* „ *subcordata*, Conrad.
- \* *Cardita* sp.
- \* *Isocardia orientalis*, Conrad sp.
- \* „ *æqualis*, Conrad sp.
- \* *Lavignon Baylei*, Coq.
- \* *Plicatula Fourneli*, Coq.

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\* This is probably *Exogyra Oltsiponensis*, as *E. Overwegi* is not known below the Danian.

† "Ordnance Survey of the Peninsula of Sinai," 1869, Pt. I.

- \* *Ostrea mermeti*.
- \* „ *plicata* Goldf. (= *O. Overwegi*, Coq., *O. Boussingaulti* Conrad).
- \* „ *Dellatrei*, Coq.
- \* *Ostrea syphax*, Coq.
- \* *Epiaster tumidus*, Desor.
- \* „ *minimus*.  
(H) *Hemiaster gracilis*.
- (H) *Holectypus excisus*, Desor.
- \* (H) *Heterodiadema libycum*, Desor.
- \* *Nucleolites similis*, Desor.  
(H) *Periaster elatus*, d'Orb.

## 2. Naqb Budra.

- \* *Arca Tevesthensis*? Coq.
- \* *Astarte Fatma*? Coq.
- \* „ *Gabæ*? Coq.
- \* (S) *Pecten asper*, Lamk.  
(S) „ *alpina*, d'Orb.  
(S) „ *tricostata*, Coq.
- \* *Ostrea plicata*, Goldf.
- \* „ *curvirostris*, Nil.  
(H) (S) *Epiaster distinctus*, d'Orb.  
(S) *Periaster oblongus*, d'Orb.
- \* *Physosoma Delamarrei*, Desor.  
(H) *Pseudodiadema Rupelli*.  
(S) „ *variolare*, Brongn.

## 3. Other Localities.

- \* *Turritella Tenouklensis*, Coq. Wadi Sadur.
- \* (S) *Pecten asper*, Lamk. Gebel Abu Alaqa.
- \* „ *Marrotianus*, d'Orb. Wadi Sadur.
- \* „ *obrutus*, Conrad.
- \* *Protocardium Hillanum*, Sow.
- \* *Ostrea dentata*, Conrad (= *O. Auressensis* Coq.) W. Ferân.
- \* „ *Mermeti*, Coq. Wadi Shellâl.
- \* „ *Dellatrei*, Coq. Wadi Shellâl.
- \* „ *Forgemolli*, Coq. Wadi Ferân.
- \* „ *vesicularis*, Goldf. Gebel Bisher.
- \* „ *flabelliformis*, Nills. Wadi Wardân.
- \* „ *costata*, Say. Wadi Ferân.
- (S) *Discoidea subuculus*, Klein. El Ti.
- (S) „ *Forgemolli*, Coq. El Ti.
- (S) *Hemiaster Cenomanensis*, El Ti.
- (S) *Periaster oblongus*, d'Orb. El Ti.
- (S) *Pseudodiadema variolare*, Brongn.

In these lists of fossils nearly all the evidence points to the age of the Cretaceous beds being Cenomanian. The occurrence of *Ostrea vesicularis*, Goldf., suggests the presence of Senonian beds in the locality where it was found. It will be seen however from the subsequent pages that this locality is not a solitary instance, this fossil having been noted in several other places all over the district.

Following this observer came Hull \* in 1883 who, however, only visited the upper part of the sedimentary area, but in the map which he publishes he perpetuates the errors of the previous observers having compiled its southern portion from the already existing sheets.

In 1888 Walther † published an account of a journey in Western Sinai in which, although his time was mainly devoted to unravelling the history of the coral reefs past and present, he gives a general account of the country through which he passed. Where he has actually examined the rocks he does not go far from the mark except in some particulars, e.g. in shewing a large area of Miocene as nummulitic limestone, and his interpretation of the structure of Qâ plain and the ranges on either side.

In 1898, the year in which the work embodied in this report was done, Fourtau ‡ published a series of papers describing the geology of Western Sinai of which the following is an epitome. In Wadi Tayiba he states that he found some marls containing the following fossils.

*Ostrea Mermeti*, Coq.

*Lucina* cf. *Safedensis*, Conrad.

*Crassatella* cf. *Falconieri*, Lartet.

*Hemiaster Heberti*, Peron and Gauthier.

From these he concludes that these marls are of Cenomanian age. As will be shown later none of these beds occur in the lower part of the wadi which Fourtau traversed, but are only found a few kilometres further south. He likewise states that a bank of diorite has cut through the Cretaceous limestone at the mouth of Tayiba, by which the beds have been metamorphosed. As a matter of fact the igneous rock is not intrusive but an interbedded lava not in Cretaceous but in Tertiary beds. At Wadi Zafarâna and Legâm the section he gives, although in the main correct, has made the limestone forming the top of the hill upper Cenomanian, whereas it has been shewn to belong to the Libyan stage of the Eocene. At this place he finds *He-*

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\* "Geol. and Geog. of Arabia Petrea," Palestine, etc., 1885.

† "Die Korallenriffe der Sinai Halbinsel," 1888.

‡ Op. cit.

*miaster cubicus*, Desor, and *Ostrea Mermeti*, these proving the rocks to be of Cenomanian age. After passing to the mouth of Wadi Budra he examined the marls which there occur in a thin strip. Here, he says, on the west side of Wadi Sêh Sidri, the Cretaceous rocks reach their maximum thickness of about 400 metres. From the marls he obtained the following fossils.—

*Hemiaster cubicus*, Desor.

„ *Heberti*, Peron et Gauthier.

*Holactypus Cenomanensis*, Gueranger.

*Ostrea Mermeti*, Coq.

*Exogyra flabellata*, d'Orb.

*Ostrea Africana*, Lam.

*Astarte amigdala*, Coq.

*Plicatula Reynesi*, Coq.

*Isoarca aquilina*, Coq.

Strangely enough these fossils are all of Cenomanian age, and the large mass of beds above these have yielded no fossils. This is as it should be, for the limestone beds which Fourtau regards as Cretaceous, are remade rocks of Younger Tertiary age, while the true Cretaceous rocks are not 40 metres thick at this place.

In describing the plain of El Qâ and the coast-range of El Araba he has evidently followed Walther as he describes it as a syncline and shews it as such in his Fig. 4, failing to recognise the fault which breaks it on the east, or the mass of Miocene beds which cap the Araba ridge, and which he shews as nummulitic limestone. In the chapter on the hydrology of this district he makes some diagrams to explain the presence of wells in certain places. In the case of the Èn el Markhâ his Fig. 6 shews a granite floor holding up the water. This differs essentially from the views formed by the writer on examination of the district. First of all he makes the Nubian sandstone to nip out within the space of a few kilometres, as none is shewn in the section, while, secondly, the granite does not exist except at over 600 metres below the surface, the whole country having been let down by a huge fault to over that extent. The true cause of the well is the holding up of the water by the shaly and marly beds of the Cenomanian. He likewise states that the springs of Hammam Farûn and Hammam Saidna Musa have the same origin. It is, however, much more likely that both of them come up fault-planes since a fault passes along the foot of Gebel Hammam Farûn, while one has been inferred at the foot of the range where the latter spring issues. From the analysis of the former water there seems little doubt that it is derived, in part at least, from the sea,

as no other hypothesis can explain the large percentage of salts in it, nor can it be understood how it derives its supply, which is perennial, from a comparatively rainless district.

Having now noticed the previous work on this district it is necessary to give an account of the observations made by the writer.

Gebel el Araba. Starting from the most southerly extension of these rocks the first to be described is the El Araba range. On entering the range a section of the main or eastern ridge was examined in which the following beds were seen, although unfavourably placed for measuring the thickness:

*Top.*

1. Limestone with flint-bands.
2. Pinkish limestone.
3. Marly limestone.
4. White limestone.
5. Flinty limestone.
6. White limestone with *Gryphæa vesicularis*, var. *judaica*, Lart.
7. Gypseous Marl.
8. Marly limestone with *Exogyra flabellata*, Goldf., and *E. Mermeti*, Coq.
9. Sandy clays and marls with calcareous sandstone.
10. Sandy beds.
11. Nodular limestone.
12. Marly beds with small *Ostræa*.

This was succeeded by the Nubian sandstone. The dip was eastwards at an angle varying from 10° to 15°.

Further up the Wadi el Araba an attempt was made to obtain an approximate thickness of these beds, but as they were steeply tilted and it was impossible to measure them on account of steep, unclimbable scarps the thicknesses here given are only approximate, being estimated by eye:

*Top.*

1. Grey marls with three thin beds of limestone ... ..	9	metres
2. Yellow marls with two metres oyster bed ... ..	10.5	„
3. Yellow shale with ferruginous limestone at top ... ..	4.5	„
4. Oyster limestone * ... ..	3	„
5. Mixture of marls and thin limestones with greenish shales at top. ... ..	15	„
6. Mixture of sandy beds and marls with a thin limestone and oyster bed. ... ..	15	„
7. Marly limestone with beds of dark shale and hard ferruginous bed at top ... ..	7.5	„
8. Nodular and thin-bedded limestone with marly partings	9	„
9. Grey sandy and marly beds ... ..	9	„

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\* See list of fossils at end of chapter.

10. Marls with bed of limestone at top full of <i>radiolites</i> ...	6	„
11. Nodular limestone ... ..	6	„
12. Sandy, marly, yellow limestone ... ..	21.5	„
13. Oyster limestone ... ..	3	„
14. „ „ with marly beds... ..	12	„

The total thickness is not less than 131 metres and may be over it. Below this series comes the Nubian sandstone which is dipping about  $10^\circ$ , while the marls above it fall away to the east at an angle of  $12^\circ$ , the overlying limestone being inclined at  $20^\circ$ . This latter dip was obtained from a very small exposure and is not to be relied upon; the general inclination is  $12^\circ$ , as deduced from several other observations.

About half-way up the range, where the upper Wadi el Araba passes out to sea, the beds have been thrown forward by a dip-fault a distance of 3 kilometres. Following up the marls from the last place at which they were examined they are seen to come to a sudden stop against the upper Cretaceous limestone, at the same time swinging round sharply until their direction of dip is at right angles to their normal bearing, their inclination rising from  $12^\circ$  to  $30^\circ$ ,  $50^\circ$  and  $60^\circ$  within the space of four kilometres. Hitherto the true limestones of the Cretaceous have been confined to the main cliff of Gebel el Araba, but beyond this fault they suddenly spread out and occupy the secondary ridges, gradually merging into the range of Qabeliat; the main cliff at the same time becomes lower and gradually loses itself in the dip-slope of this hill-mass. To the south of the fault the conditions are reversed; the limestones form the cliff only; while the marls occupy a series of parallel ridges at its foot, each ridge being due to the limestone beds noted in the above section.

To the north of the dip-fault there is a steep escarpment of the marls sharply tilted to the north at an angle of about  $80^\circ$ , which bends round until it assumes a direction parallel with its original line. The Cretaceous limestone also owes its great horizontal extension to reduplication by step-faulting, the throw never being great enough to bring up the marls. The general trend of these fractures is more or less parallel with the main cliff, and in no case do they cross the dip-fault. The most westerly ridge is capped by Miocene deposits underlain by nummulitic limestone (*N. Gizehensis*) which directly overlies the Cretaceous limestone.

The Miocene lies in the form of a shallow syncline on the top, while the Cretaceous limestone shows dips ranging from  $22^\circ$  to  $35^\circ$  to the east. The fault which has thrown down this ridge is evidently conti-

nued in the direction of Qabeliat where it dies out, the wadi of this name having formed along its course. Further to the east two more faults were found parallel to this one, the throw of each of this series, as determined by the position of the nummulitic bed being 49 metres, 30.5 metres and 104 metres, going from west to east. For the general appearance of the rocks at this place see Section I. In all the sections here the nummulitic beds were found between the Miocene and Cretaceous, although some distance further to the south they were missing.

Gebel Qabeliat. Passing north to the hill-mass of Qabeliat \*, it is convenient for descriptive purposes to separate it from the Cretaceous to the north of Wadi Ferân, making this valley the northern boundary for the present. This hill-mass presents on its western face a steep escarpment which is unscalable in many places, and is cut up into narrow ridges by deep gullies sloping eastward; it is capped on the north, where it was examined, by Miocene limestone, the southern ridges having lost this covering. The nummulitic bed was not seen beneath the Miocene at this point, but it must exist in places, as it was found thrown down against the marls farther south. Forming secondary ridges at the foot of the escarpment are the marls with the Nubian sandstone at their base. In the main mass it was impossible to get a measured section, but the succession was very similar to that in Gebel el Araba. The marls dip eastward at an angle of  $18^{\circ}$ , while the overlying limestone is less steeply inclined. In the nodular bed in the marls specimens of *Nerinea* were found, associated with these being several ammonites. Further to the south, a north and south fault has thrown down the Cretaceous limestone and marls against the Nubian sandstone.

On the north side of Qabeliat on the side of Wadi Ferân a section was examined in which the following beds were noted:

Top.			
Miocene	1.	Crystalline limestone with small echinids and a thin layer of large oysters ... ..	9 metres
	2.	Limestone with echinid spines. ... ..	3 "
	3.	Limestone with foraminifera ... ..	3 "
	4.	Limestone with thick oysters and large pectens ... ..	3 "
	5.	White, thin-bedded, marly limestones which weather into thin leaves ... ..	61 "
	6.	Marly limestone with flinty layers ... ..	28 "
	7.	White sandy limestone ... ..	73 "
	8.	Marly limestone with few flints ... ..	18 "
	9.	Marly limestone with flints ... ..	37 "
Total Cretaceous ... ..			<u>217</u> "

\* See list of fossils at end of chapter.

Underneath these comes the lower limestone of the Cretaceous which as it formed the surface of the ground could not be measured here, the marls following in due order.

The hill-mass of Qabeliat is evidently the top of an anticline as there is a fall from the top to the north and south, Wadi Ferân being in the trough; it thus seems that the course of the drainage has been determined by this fold, and not by faulting, as maintained by Walther, for which there is no evidence.

It is now necessary to describe the mass of Cretaceous rocks which Gebel Safariat. occurs on the east of Qâ plain, and lies on the flank of the igneous and metamorphic rocks of the central range. Taking the most southerly part of this area—Gebel Safariat—it is found to be much complicated by folding and faulting. It is composed of nummulitic beds on the east side followed by Cretaceous limestone and marls, these latter being reduplicated by faulting. The beds dip steeply towards the hills, being let down by the main fault which runs between the sedimentary and igneous rocks the whole distance in which they are in juxta-position. Walther \* and Fourtau † give quite a different interpretation of the structure of this area. In the section by the former he shews this area to be a simple anticline broken by the main fault along the edge of the hills, the range of El Araba being connected to it by a syncline. In this section he shews Eocene rocks on the east side, which is correct, but he can hardly have examined the rest of the rocks, as the beds, instead of dipping west as he shows them, have a strong easterly dip, and instead of Cretaceous limestone forming the west side, it is bounded by the marls. The section of Fourtau, although the place is not quite identical with that of Walther, resembles certain of the latter's sections, but he makes nummulitic limestone appear on both sides of the hill, which does not agree with the facts of the case, there being no evidence to enable any one to deduce an anticlinal structure for this area.

The following is a detailed description of this hill. On the east side, as previously stated, it is covered by nummulitic beds dipping steeply eastward at an angle of  $50^{\circ}$ , which also extend some distance on the south side. Underneath these comes the limestone of the Cretaceous which seems to pass insensibly into the overlying beds although the dip as seen a little further back is much smaller. The general appearance of the area points to the conclusion that this has at one time been a dome subsequently broken by a big fault and much disturbed by

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\* Op. cit.

† Op. cit.

smaller ones, the main fracture being connected with that which has let down the beds on the east side of the Qâ plain.

In the middle of the area the marls are lying almost horizontal while towards the north they are inclined in that direction at an angle of 15°. The following is a section of the limestone with some measured thicknesses and the others estimated by eye.

Top.

1. More or less crystalline limestone containing <i>Nummulites Gizehensis</i> and corals ... ..	21.5	metres
2. Beds full of <i>Thersitea</i> casts ... ..	3	"
3. Hard crystalline limestone with soft partings and containing fossils near the top ... ..	11	"
4. Shelly, marly limestones. These are Eocene in age...	5.5	"
5. Coprolite-bed with fish teeth ... ..	1	"
6. Shelly, marly, crystalline limestone containing dog-tooth spar... ..	12	"
7. Hard crystalline beds with layers of flint ... ..	31	"
8. White chalky limestone with numerous thin layers of flint ... ..	18	"
9. White, chalky limestone with <i>Gryphæa vesicularis</i> var. <i>judaica</i> , Lart. ... ..	9	"

Below this come the Cretaceous marls.

On the west of the main escarpment where the above section was examined, a small knoll of the *Gryphæa vesicularis* limestone is let down by a fault against the marls and has a dip of 50°. On the extreme west of this area these beds again appear let down along a north-and-south line and having a steep dip of 50° on either side of the fracture. On the north side a small patch is also found dipping north-east at 30°.

In the marls there is a general dip (where not disturbed by faults) of 10° to the south-east; but on the north side, where they come under the influence of faults, they are inclined at angles of 8°, 15° and 30°, north-west, north and north-east respectively. Two faults run more or less east and west down the wadis, and it is due to these that the marls occupy so much of the ground. In these beds a good many echinoderms, *radiolites* and *Ostrea* occur.

Gebel Asfar.

Passing northwards the main sedimentary area is first touched at Gebel Asfar. At its base the whole of the succession found in Gebel Safariat except the Coprolite-bed is seen. In climbing the hill the marls are seen dipping towards the igneous range at an angle of 30°; but as the limestone was crossed, the beds were seen to go under the Miocene of Gebel Asfar in a north-easterly direction at an angle of 20°. North of this hill in Wadi Raqqa the marls are seen inclined away from

the hills at an angle of over  $60^{\circ}$ , while the overlying limestone dips at  $30^{\circ}$ . On the west side of the ridge, however, the opposite is seen, the limestone dipping at  $50^{\circ}$  towards the hills, thus showing that there is an extremely sharp fold which has been broken by the line of fault bounding the igneous rocks. This fold is continued more or less parallel with the hills but the dips are not nearly so steep, being  $8^{\circ}$  and  $5^{\circ}$  respectively east and west.

From Gebel Asfar to the mouth of Wadi Abûra the marls form the sides of the hills, but in this wadi Miocene beds are found capping them, and lying unconformably on the *Gryphæa* limestone and the marls. Between this hill and the high plateau to the east the marls extend in a fairly broad strip, being evidently exposed by the breaching of the anticline of Cretaceous limestone, which appears in the plateau to be about 183 metres thick.

On the north side of Wadi Abûra a long strip of Miocene deposits rests on the marls which have a general trend to the south, the land rising and the limestone coming in and thickening as it is followed northwards. This is capped by the nummulitic bed which lies in a shallow syncline, and is let down along the side of Wadi Thaghadi against the marls. Between Wadi Abûra and Abu Gurdi the marls on each side of the plateau are dipping south at  $15^{\circ}$ ; while at Gebel Thradi which forms the divide between the latter wadi and that of Thradi, there is a patch of Cretaceous limestone dipping south-west at angles of  $50^{\circ}$  and  $60^{\circ}$ . Further north where the marls are exposed, their dip is over  $80^{\circ}$ ; while only a little distance back at the top of Gebel Thaghadi they are only inclined  $5^{\circ}$ . It thus seems fairly certain that this steep dip is the result of a fault which has broken the syncline, dragging down the beds as they gave way.

In this section the beds appear in a very sharp flexure on the up-throw side of the fault, while immediately behind this they are lying horizontal. It would seem that when the flexure which ended in a fracture became acute, the beds offered such a strong resistance to it that they were dragged almost into a vertical position before they finally gave way. This points rather to a comparatively sudden movement, than a slow, gradual flexure and fracture.

On the north side of Wadi Thaghadi another small patch of Cretaceous limestone occurs dipping at  $80^{\circ}$ , while behind it the marls are inclined at  $5^{\circ}$ ; the relations of the beds at this point are shown in Section I.

Wadi  
Thaghadi.

North of Wadi Abiad occurs Gebel Abiad, a hill of Cretaceous limestone tilted at  $80^{\circ}$  to the south-west, and presenting a steep scarp to the

Gebel Abiad.

north-east. There is a small fault behind this hill throwing down to the east which is continued across Wadis Themâm and Abu Gallam behind Gebel Khadâhid.

Gebel  
Khadâhid.

In this hill the following sequence was seen in the wadi of the same name, the beds having the same steep dip at first, but falling back rapidly to a gentle slope :—

Top.

1. <i>Nummulites Gizehensis</i> bed with various oysters, echinoderms, and foraminifera over	...	...	30 metres (Eocene)
2. White, marly, fissile limestone, about	...	...	21 „
3. White limestone with layers of flint	...	...	18 „
4. Hard, white, marly limestone with fissile partings, about	...	...	76 „
5. White marly limestone weathering pink, with flint layers at top.	...	...	9 „
6. Thin-bedded flinty limestone	...	...	6 „
7. White, chalky limestone with <i>Gryphæa vesicularis</i> var. <i>judaica</i> , Lart.	...	...	9 „
Total	...	...	<u>169 metres</u>

As will be seen the thicknesses are not accurately determined and must not be taken as absolute.

Wadi Ferân.

The next place where this area was examined was in Wadi Ferân,\* where a large mass of flinty limestone slopes westward to the wadi, culminating in the peak of Gebel Asl. These flinty limestones dip westward at 22°, and end in an abrupt escarpment which tapers to such a narrow edge at the top that it is dangerous to attempt to walk along it, while it is impossible to walk on the slope of the flinty beds on account of their slippery surface. The height of Gebel Asl above the wadi level is 460 metres which, taking the dip as 22° as determined, and plotting it out on paper, shews a thickness of 420 metres of limestone. This seems rather exaggerated but as the height was obtained by aneroid in descending the cliff there may be a slight error. At the same time it is fairly near that given by Schweinfurth for the limestone in Wadi Araba, viz. 380 metres.

On the south side this limestone swings round to the east evidently forming the remains of a dome, and is cut off by a fault running in an east-and-west line, the marls being brought up against it.

At the foot of this escarpment the marls come out and rise towards the east with a slope of 25°. Further east is another ridge of limestone

\* See Section II.

of the same nature as the first, rising in terraces from the wadi, and dipping westward at  $32^{\circ}$ . It is let down by a fault against the marls, this being accountable for the very steep dip. On the highest point occurs a patch of Miocene which, with the *Nummulites gizehensis* bed, lies in a sharp syncline broken by the fault throwing down the Cretaceous limestone against the marls, the nummulitic bed being let down against the *Gryphæa vesicularis* limestone and the upper beds of the marls. The Cretaceous limestone is evidently continuous underneath this patch and forms a sharp, V-shaped bend, the east limb of which dips  $32^{\circ}$  to the west, and forms a steep scarp facing east. At the base of this the marls are seen, but when followed northwards they narrow and are finally nipped out by a fault running north-west-south-east, which has thrown down the nummulitic bed and the *Gryphæa vesicularis* limestone against them. This fault is continued across Wadi Ferân and dies out at the head of Wadi Mokateb. Underneath the nummulitic beds and the Cretaceous limestone, the marls again appear on the east side, forming a fairly high escarpment, and they occupy both sides of the wadi at this point, their dip below the overlying beds being  $15^{\circ}$  to the west. Further to the south-east, the cliff of Cretaceous limestone which lies immediately behind the Miocene becomes connected with the main mass of which Gebel Asfa or Asl forms the summit, the high limestone area abutting on the gneiss and granite of the main range, and being let down by the main fault. Along the edge of the fault it is capped by the nummulitic beds which dip towards the fault at angles varying between  $20^{\circ}$  and  $30^{\circ}$ .\* To the west of the limestone is a large area of marls which occupies the country from the neighbourhood of Wadi Thaghadi, up to the fault which throws down the limestone of Gebel Asfa against them. On the east side of the limestone ridge the marls, as they are followed to the south-east, are gradually nipped out by the fault which here has a fairly large downthrow.

It is now necessary to consider the origin of Qâ plain. Walther † is the only one, as far as is known, who has made a definite statement illustrated by diagrammatic sections, while Fourtau ‡ has followed his lead. Their explanation is, that it is a syncline in which Newer Tertiary deposits have been laid down. On referring to Section I however, which has been drawn to scale, it will be seen that instead

Gebel el  
Rigma.

† Origin of Qâ  
Plain.

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\* See Section I.

† Op. cit.

‡ Op. Cit.

of the nummulitic beds lying on either side of the trough as shown by Walther, they are covered by Miocene beds, on the west side much step-faulted, while on the east both of these formations are absent, having been thrown down under the surface by a large fault, and the Cretaceous limestone has been tilted at  $80^{\circ}$  by the fracturing of the beds. At the head of the plain near Wadi Ferân where the fault dies out, the conditions are more those of a syncline, although even there the beds occupying the opposite sides of the trough are not the same. From observations made in the vicinity it would seem that they had been originally homologous, but were removed later on by denudation.

It was Blanckenhorn \* who evidently was the first to suggest the true state of matters from a study of Walther's map, and taking into consideration the fact that he had never visited the country, his deductions were wonderfully correct. In his paper he suggested that a fault had broken the syncline on the east and let it down, and this agrees with the observed facts. This paper will be referred to when the faults come to be described. There can be little doubt as to the correctness of the explanation here given, and it would seem probable that the above mentioned writers without having examined the ground, have formed their conclusion from insufficient data possibly collected on the sides of Wadi Ferân.

Gebel Withr.

Passing to the north of Wadi Ferân and following the plan of the description of the previous part, the coast-ranges of Gebel Withr, etc., fall next to be described. On the side of Wadi Ferân a section has already been given showing the succession of the beds in the limestone (p. 138). Gebel Withr is a ridge having a steep escarpment facing the west with the beds dipping eastward at  $10^{\circ}$  to  $15^{\circ}$ . It is composed of flinty limestone with the *Gryphæa vesicularis* bed at the base, and the marls, part of which is only visible, forming low foot-hills on the coast. On the east, the limestones have been thrown down against the marls by a north-and-south fault hading west; while on the coast a second fault has let down the nummulitic beds and the Miocene deposits against the marls, this fracture evidently continuing along the coast side of the range as far as the mouth of Sêh Sidri. On the side towards this valley the range is split into two by a wadi, the western part being known as Gebel Nisisat,† while the other retains the name of Withr. On the north side these ridges run to earth, being let down by a little cross-fault which connects the longitudinal fractures. No fossils were

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\* "Die Strukturlinien Syriens u. d. Roten Meeres," 1893.

† See Section III.





GENERAL VIEW OF FAULT EFFECTS AS SEEN FROM NAGB BUDRA.

observed in the flinty limestone ; but in the marls below many specimens were obtained. On the east of Gebel Withr the *Gryphæa* limestone and the upper part of the marls where they are exposed from under the Miocene, are seen to be gypsumised. This will be described in the part on Gypsum. These gypsumised marls disappear under the Miocene limestones and marls.

On the east side of the Miocene deposits above-mentioned, and on the north side of Ferân the Cretaceous limestone (which is the continuation of the mass described on the south side, p. 142) forms a large mass having the same characters as those already mentioned, and a dip of  $22^{\circ}$  W. This mass gradually tapers to the north and is eventually nipped out by a fault. On its west and north-west sides the nummulitic bed \* lies on it at an inclination varying from  $32^{\circ}$  to  $10^{\circ}$  to the west and north-west respectively. Below the limestone come the marls † with a fault breaking them in the middle. Further north their outcrop suddenly narrows to a mere strip, this being due to the fault previously mentioned which throws the limestone down against them. This narrow strip continues right along to the foot of Gebel Abu Alaqa where it disappears, being covered by the Miocene deposits which cap that hill.

In this wadi the Cretaceous marls appear at the mouth in a thin Wadi Budra, streak which gradually widens out into a triangular patch, its dip at first being  $25^{\circ}$  to the west, but gradually lessening until its outcrop ceased to expand. Near the head of the wadi a small patch of the *Gryphæa vesicularis* limestone crops out from under the Miocene deposits ; while just beyond the Naqb Budra, the marls rise in a fairly high hill, the base of which is formed by the Nubian sandstone. In this hill in the marls there is a bed of limestone in which occur numerous echinids and ammonites. This is in the lower half of the marls. Beyond this hill the marls widen out, being reduplicated by two short, parallel faults. To the west these marls dip away under the Miocene at  $5^{\circ}$ , being covered in many places by a bed of gypsum derived from the *Gryphæa vesicularis* bed. Further to the east a small strip of unaltered limestone appears on the edge of the Miocene deposit, while on the edge of the latter which lies opposite the Wadi Shellâl,\* a strip of Cretaceous limestone forms the edge of the basin in which these beds lie, being inclined to the horizon at an angle of  $63^{\circ}$ , and let down by a fault against the Nubian sandstone. While, on the east side, these beds are tilted steeply, on the west they lie almost horizontal, having

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\* See Section II.

† See list list of fossils at end of chapter (Wadi Kaba).

Gebel Hadûd. only a slight dip eastwards. If followed southwards, however, they gradually rise higher and higher, culminating in Gebel Hadûd which has a dip of  $15^{\circ}$  to the south-east, and is let down by the fault above mentioned. It consists of thin-bedded flinty limestone into which a few veins of a glassy basalt have been intruded. To the west and north-west it presents a steep escarpment which is almost entirely covered by blown sand, thus making the descent easy. This is true for the whole of the patch on either side of Seh Baba. Along the side of Wadi Shellâl, and at the mouth of Wadi Baba, the Cretaceous marls are partly visible below the limestone, the other part being carried below ground by the main fault.

The way in which the Miocene is deposited in this basin is somewhat peculiar. Instead of the beds on the west being bent or worn into the form of a trough, as the appearance on the east leads one to expect, they are broken right through and the Miocene\* is laid horizontally against the ends. It may be that a fault exists under these younger beds, but there is no conclusive evidence. Crossing the plain of El Markhâ, the plateau on the north side is found to consist on the east of Cretaceous limestone which has been faulted down below the Carboniferous limestone occupying the top of the ridge to the east. Further west near En el Markhâ the limestone ends in an escarpment and the marls appear dipping under the limestone at  $7^{\circ}$  in a north-easterly direction. Working seawards a sharp fault is met with, by which the limestones are thrown down against the marls and Nubian sandstone; it dies out near the head of Wadi Nokhl. This is in all probability a broken anticline, as the marls are steeply tilted and the sandstone appears high in the cliff. Towards the fault, i.e. north-east, the beds on the downthrow side are dipping at an angle of  $16^{\circ}$ ; while those on the north side of Wadi Nokhl dip  $25^{\circ}$  to the south-east, this being apparently due to the downward drag produced by the above-mentioned fault. Near the mouth of Wadi Nokhl a dyke of dolerite cuts the limestone in a north-and-south direction, and runs out to sea a little further south. At this point there is scarcely any beach, the limestone escarpment almost touching the water at high tide, while further to the north the water washes the foot of the cliff.

Further to the north, the Cretaceous limestone escarpment bends sharply round at right angles to its previous direction, exposing the marls in a small area which is an anticline, there being a dip of  $10^{\circ}$

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\* See Section VI.

towards the sea in the limestone ; while the marls and eventually the limestones disappear under a beach deposit (Miocene) to the east. The dyke previously mentioned is again seen here and is lost for the present under the beach deposit which contains a contemporaneous lava flow.

Further north near the mouth of Wadi Tayiba the marls give place to the limestones, and these are covered by the above-mentioned deposit. Passing up Wadi Tayiba its sides are composed of vertical cliffs of the flinty limestone of the upper Cretaceous which are dipping about  $17^{\circ}$  towards the sea. The general arrangement of the beds in this area is shown in Section V. From it it is seen that the limestones here reach a thickness of 500 metres, and that only after modifying the dip somewhat, as the general conditions of the district do not warrant the assumption that the dip of  $17^{\circ}$  is anything but superficial, the inclination rapidly becoming less as the beds pass towards the centre of the trough. The structure of the country here is a combination of two sets of folds, the main one having its axis north-west south-east, parallel to the Gulf of Suez, while that of the other lies more or less east-and-west. The sides of the main fold are much more steeply inclined, while the other has gentler inclinations with consequently wider intervals between the folds. In the main fold, beyond the slight fault which is met with in the hill capped by the Miocene, the dip is  $10^{\circ}$  towards the sea and  $5^{\circ}$  away from it. This is not shown in the section as the line passes through a node formed by the two sets. Further up the wadi, the second class of fold shews little or no dip as the wadi happens to be in the centre of the syncline at that point. In the wadi at the foot of the Miocene-capped hill, small cracks in the limestone were found lined with sulphur and gypsum. Further up the wadi the dyke (p. 140) previously mentioned was again met with in Wadi Hamr and continued its course in a north-easterly direction for some distance, but it apparently dies out before it reaches Wadi Ethal as it was not seen there. This dyke is 5 to 6 metres thick and at its junction with the limestone it is tachylitic, while the latter rock has developed hydrocarbons. This is the case with every intrusion into this limestone. Besides this dyke small veins of basaltic rock were met with in two other places in the wadi. As the rocks are crossed in an easterly direction it is seen that they are in descending order until the basal bed (the *Gryphæa vesicularis* limestone) is found on the side of the fault capped by the beach deposits in Gebel Sarbut el Gemel, the general dip being  $4^{\circ}$  N.W. On the edge of the fault the dip is much steeper, being  $40^{\circ}$  in the same direction.

On the south side of Wadi Hamr the limestone is seen dipping at  $30^\circ$  towards the fault which has thrown it down against the Carboniferous, while there is a dip of  $7^\circ$  N. W. Nearer the wadi a small patch of marls is seen on the upthrow side of the fault, which is broken by two small faults hading east, and having a throw of about 30 metres each. On the other side of the wadi the limestone shews a dip of  $8^\circ$  to the south-west. Practically the whole of the country on the downthrow side of the fault between Wadis Hamr and Ethal is made up of Cretaceous limestone.

To the north of Sarbut el Gemel the Cretaceous marls have been let down by an offshoot of the main fault against the Nubian sandstone, and tilted at angles of  $30^\circ$  to  $40^\circ$  towards it. Another line of fracture more or less parallel with the other, but which eventually fuses with it, lets down the marls to the west forming a trough-fault, dips of  $30^\circ$  also being seen. Further north the fracture dies away, and the marls rise above the sandstone to their normal position. Following up the boundary between the two, a small patch of the *Gryphæa vesicularis* limestone is found lying against the Nubian sandstone, having been let down by a fault from the plateau above. The marls at Ras Ethal\* form a plateau bearing the name of Gebel Abu Dêmat. Here the top members of the series are absent, and the general dip is  $5^\circ$  to  $6^\circ$  E.

In the limestone beds here several kinds of echinids were found as well as ostrea. Associated with the echinid bed is another also full of spines and echinids; it is highly crystalline and often stained a dark amethyst colour by manganese compounds. To the north of Ras Ethal the marls bend over sharply from the top of El Ti and join those of Abu Dêmat and Gebel Madsûs, the fault which ran along the foot of the cliff having died out.

Gebel el Ti.

The upper half of the cliff of El Ti, from Gebel Dhalâl to this point, is made up of Cretaceous marls; in the latter hill there is a thickness of 98 metres of these beds, but as they were much crystallized in the more calcareous beds it was difficult to recognise the fossils. The *Nerinea* which was found in Gebel Qabeliat and other places was seen here. Bauerman† and Le Neve Foster, in their expedition in this district, measured a section further north of which the following is the sequence:—

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\* See list of fossils at end of chapter.

† Op. cit. p. 26.

*Top.*

1. Limestone and marl, some chloritic and some with flint nodules ; a hard bed near top ... ..	30·5 metres
2. Tumbled stuff ... ..	15 "
3. Compact limestone ... ..	6 "
4. Tumbled stuff ... ..	12 "
5. Calcareous sandstone with nodules of alabaster ... ..	15 "
6. Limestone and shales with large <i>Ammonites</i> ... ..	30·5 "
7. Hard limestone and shales with rubbly bed containing <i>Hippurites</i> with ferruginous sandy bed at top ... ..	30·5 "
8. Hard, compact, cream-coloured limestone ... ..	3·75 "
9. Shales and sandy shales with gypsum, and thin nodular limestone at top ... ..	30·5 "
10. Coarsely-bedded sandstone ... ..	6 "
11. Shaly beds ... ..	15 "
<hr/>	
Total ... ..	194·75 metres

On the north side of Wadi Ethal the marls slope down from Gebel el Ti at an angle of 5° or so and run to earth at the foot of the limestone escarpment of Gebel Krêr, and continue through Gebel Hiâla up to and beyond Wadi Abu Qâda.

This hill consists of two ranges on the south side which fuse into Gebel Krêr. one as Wadi Abu Qâda is approached. Its eastern member consists mainly of Lower Libyan limestones laid on the *Gryphæa vesicularis* bed. To the west of this comes a patch of Cretaceous marls let down against the Libyan beds by a fault—the continuation of the main fracture. The Libyan beds dip steeply at first at 40° but this falls rapidly to 8° as the fault is approached. In the marls the dip is at first 5°, but before they disappear under the second ridge of Krêr they take on suddenly an inclination of 15°. Here it was noticed that deeper-water conditions had evidently existed, as shewn by the fusing together of two separate limestone beds, and the exclusion of an intermediary marl, thus giving a limestone of respectable thickness. In this bed many *Cyphosomas*, *Pseudodiademas*, etc., were collected. In the second ridge of Gebel Krêr, at the top of the *Gryphæa vesicularis* bed, a nodular layer was seen in places between it and the overlying Eocene. In Section IV, the general relations of the beds are shewn.

Passing down Wadi Ethâl it is found that the Cretaceous limestone is only represented by the chalky bed which forms its basal member, the upper beds having disappeared. This bed evidently forms a flat syncline in which the Eocene beds were laid down, and from which they had been subsequently eroded before the deposition of the Newer Tertiaries. In this syncline are many patches of shallow-water beach

Hamman-  
Usêt Range.

deposits. In the plain up which the Suez-El Tor telegraph line goes, there occurs a shallow basin in which Beach deposits have been laid down. From underneath these rise up beds which are in all probability Eocene, and pass into the Hammâm-Usêt range which is composed mainly of nummulitic rocks. There is, however, a difficulty in determining the exact boundary between the two rocks, and it is difficult to account for the apparent absence of the great thickness of limestone which was present in Wadi Tayiba. It is likely (although difficult to prove by examination in the neighbourhood of the hot springs which issue from the base of the cliff) that the basal limestones of the Cretaceous constitute the base of the coast-range, and it has been assumed, in the absence of proof to the contrary, to be so. Section IV shews the interpretation of the structure of this range.

Country  
between Wadi  
Ethâl and  
Gharandel.

Between Wadi Ethâl and Gharandel, Cretaceous limestone is exposed along the hollows between the ridges of Newer Tertiary deposits. Further up the latter valley, to the east of the gypsum hill of Gebel Gushia, the limestone is the basal bed of the Cretaceous limestone. This limestone also formed the base of Gebel Abiad and the low ground close by, where dips of  $12^{\circ}$  S.W., and  $8^{\circ}$  N.W. were seen. To the east of Gebel Abiad the Cretaceous limestone has been carried forward by a dip-fault, and the basal limestone with its overlying Eocene has been thrown down by the main fault to the west. Beyond this the marls have been much disturbed by faults. First, the dip-fault above-mentioned runs along the wadi causing a horizontal displacement; secondly, a strike-fault breaks them parallel to Wadi Wuta thus exposing the Nubian sandstone; and thirdly, another throws down the upper marls to the west; this fracture eventually meets the main line and becomes a part of it. The main cliff of El Ti is composed of the marls of which nearly all the upper members are present.

Passing north towards Wadi Bagha, a dyke was found in the marls which has evidently not cut its way through the overlying limestones, as it does not penetrate the entire thickness of the marls.

Behind Gebel Abiad a small patch of the marls is evidently brought up through the limestone by a fold; while the basal member of the Cretaceous limestone forms a sort of setting to the patches of upper Eocene which cap the hills here.

A little distance further north at the end of this hill, it was found that the Cretaceous beds had been replaced by nummulitic limestone and from this point northwards they were not again met with. The marls continue to occupy the cliff of El Ti as far as Gebel Bisher, but are

never seen in the plain. There must have been a considerable amount of overlap during the deposition of the Eocene in this area, as it is found lying on different beds, while, as has been shown in the chapter on the Eocene, nearly the whole series from top to bottom is found within a few kilometres.

*Age of the Cretaceous beds.*—Concerning the age of the Cretaceous series of the rocks found in Sinai, there seems to be a fairly general consensus of opinion amongst geologists. All are agreed as to the presence of a considerable thickness of Cenomanian beds; but as to the presence of Turonian beds different writers are not in agreement. Rothpletz states that no Turonian exists in Sinai; while the late Dr. Duncan considered that there were grounds for the belief in the presence of these beds.

The presence of Senonian beds is proved by the numbers of *Gryphaea vesicularis* in the white chalky limestone at the base of the mass of flinty limestones about 400 metres thick. Whether these limestones belong entirely to the Senonian, or partly to the Danian also, is impossible to determine, as this great mass of rock is remarkably unfossiliferous.

*Gypsumised Cretaceous rocks.*—It now remains to describe those rocks which have undergone alteration into gypsum. The first occurrence noted was on the eastern slope of Qabeliat where the Miocene deposits had been removed by denudation. It was evidently a part of the Cretaceous limestone which had been altered. The main patch, however, occurs to the north of Wadi Ferân and forms the floor on which lie the Miocene deposits. It appears in the cliff composed of these rocks which overlooks Wadi Withr. When examined it is seen to consist of a more or less pure bed of gypsum at the top, below which come marly beds having a great resemblance to the Cretaceous marls. Further north, in the northern Wadi Withr, a section of these rocks was seen in Gebel Morr. At the top came the Miocene deposits followed by gypsum, beneath which came gypseous marls, these finally passing into unaltered Cretaceous marls. That this is the work of water seemed undoubted, as the marls are veined in all directions with strings of small crystals of this mineral; while the hard compact limestone beds have been in many places entirely recrystallised, and changed into aggregates of small plates of gypsum. In the report of the Eastern Desert\* it was pointed out that the gypsum in that area was closely

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\* "Topogr. and Geol. of the East. Desert of Egypt, Central Portion." Cairo, 1902, p. 196.

associated with the Beach deposits, and, it was believed, owed its origin to them. In the area under description clear evidence was found proving that the alteration had proceeded from above downwards, for when a section was examined, the gypsumised marls were found to pass into marls containing gypsum, and finally unaltered rocks containing Cretaceous fossils round which were little clusters of gypsum crystals. No further evidence is needed to establish this explanation, and dispose of the theory of gases rising from below as the metamorphosing agent.

These beds occur under the Miocene deposits wherever the latter have been removed, while their unaltered representatives are often seen standing out beyond the area in which the latter have been deposited. To the north of Sêh Sidri they form an irregular triangular patch where the Beach deposits have been removed, and are underlaid by the unaltered marls as in Wadi Withr. At the base of Gebel Hadîd they are cut off by the fault which throws down the Cretaceous limestone and the Miocene deposits.

These beds are the metamorphosed representatives of the *Gryphaea vesicularis* limestone, and the upper half of the Cretaceous marls. In this they differ from those on the western shore of the Gulf of Suez, where in nearly every case the lower limestone of the Eocene was included with the upper member of the Cretaceous.

Although it has been clearly established that the alteration into gypsum is from above by the agency of water, yet there still remain some inexplicable points. For instance, in no single case which came under the writer's observation, where the *Nummulites Gizehensis* bed underlaid the Miocene deposit, was this bed gypsumised. At first it seemed as though different conditions existed in these areas, but this idea was soon disposed of when the Cretaceous and the nummulitic beds were found underlying the younger deposit in one area, where the former were gypsumised, while the latter remained unaltered. Whether it be that the numerous fossils in the latter render it less amenable to the action of water is uncertain; it may be that it allows the water to pass through more easily than the closer and more compact chalky rock of the Cretaceous. Or perhaps the better explanation is that the more finely divided chalky nature of the Cretaceous limestone renders it much more liable to alteration by percolating water, than the more compact, semi-crystalline nummulitic limestone.

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## FOSSILS

DETERMINED BY R. B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

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### Gebel and Wadi Qabeliat.

- Nerinea olisiponensis*, Sharpe.  
*Ostrea* (?) *alicula*, Hamlin.  
do. *flabellata*, Goldf.  
do. *Africana*, Lam. sp. = *O. Auressensis*, Coq.,  
*O. suborbiculata*, Lam. sp. = *O. Mermeti*, Coq.  
*Plicatula Reynesi*, Coq.  
Cast like *Glycimeris Marrotianus*, d'Orb. sp.  
" " *Cucullæa Ligeriensis*, d'Orb.  
= *Arca indurata*.  
*Sphurrulites Lefebvrei*, Bayle.  
*Salenia Batnensis*, Peron and Gauth.  
*Hemiaster scutiger*, Forbes.  
do. *Heberti*, Coq.

### Gebel Safariat.

- Tylostoma globosum*, Sharpe.  
*Ostrea* ? *alicula*, Hamlin.  
do. *Africana* Lam, sp. = *O. Auressensis*, Coq.  
do. *suborbiculata*, Lam. sp. = *O. Mermeti*, Coq.  
*Gryphæa vesiculosa*, J. de C. Sow. = *G. Vesicularis* var. *judæica*, Lart.  
*Sphurrulites Lefebvrei*, Bayle.  
*Diplopodia* ? *variolare*, Brong.  
*Linthia oblonga*, d'Orb.  
*Coptophyma problematicum*, Peron and Gauth.

### Gebel and Wadi el Araba.

- Ostrea* like *lignitarum*, Coq.  
do. *flabellata*, Goldf.  
do. *Olisiponensis*, Sharpe.  
do. *Africana*, Lam. sp.  
do. *suborbiculata*, Lam. = *O. Mermeti*, Coq.  
do. sp.  
*Gryphæa vesiculosa*, J. de C. Sow.  
*Sphurrulites Lefebvrei*, Bayle.  
? *Diplopodia*.  
*Linthia oblonga*, d'Orb.  
Coral like *Thamnastræa decipiens*, Mich.

### Wadi Raqqa.

- Hemiaster scutiger*, Forbes.

**Wadi Thaghadi.**

- Ostrea olisiponensis*, Sharpe.
- do. *africana*, Lam. sp.
- do. *suborbiculata*, Lam. sp.=*O. Mermeti*, Coq.
- Sphærulites Lefebvrei*, Bayle.
- Diplopodia variolare*, Brong.

**Wadi Esba.**

- Ostrea olisiponensis*, Sharpe.
- Plicatula* allied to *batnensis*, Coq.
- Holcotypus excisus*, Desor.
- Linthia oblonga*, d'Orb.
- Hemiaster scutiger*, Forbes.
- do. *Heberti*, Coq.

**Nagb and Wadi El Budra.**

- Ostrea olisiponensis*, Sharpe.
- do. *africana*, Lam.
- do. *suborbiculata*, Lam. sp.
- Heterodiadema libycum*, Cotteau.

**Wadi Ethal.**

- Ostrea flabellata*, Goldf.
- do. *africana*, Lam. sp.
- do. *suborbicula*, Lam. sp.
- Sphærulites Lefebvrei*, Bayle.
- Diplopodia* ? *Sinaicum*, Desor.

**Wadi Silfa.**

- Ostrea rediriva*, Coq.
- Plicatula* allied to *batnensis*, Coq.
- Linthia oblonga*, d'Orb.

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SECTION V.—THE NUBIAN SANDSTONE.

Under this heading are grouped all the rocks which come between the Cretaceous marls and the Carboniferous beds. They consist of a mass of sandstones varying in colour from a dazzling white, through pink and red to dark-brown, and singularly remarkable for the entire absence of fossils in them.

Russeger \* described the sandstones occurring in Egypt and Nubia as "Nubian Sandstone," and in his maps of Egypt, Nubia and Arabia

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\* "Reisen in Unter Aegypt. auf d. Halbinsel d. Sinai &c.," Vol. III.

Petræa coloured it as Lower Cretaceous. In the text of his book he makes no positive statement, but says that the beds in question are not younger than Lower Cretaceous.

In 1864, Figari Bey \* described the sandstones occurring in Egypt, Sinai, and in the neighbourhood of Aqaba. In Sinai he mentions the tripartite arrangement of the series (two sandstones with a thin limestone between them). He assigns a thickness of 850ft. to the sandstone of Aqaba. In Sinai he regards the whole series as being of Triassic age. He considers the limestone as representing the Muschelkalk, although his reason for this determination is not quite clear. Perhaps the resemblance in position of this limestone to the Muschelkalk may have been the reason for the above determination.

Bauerman † in 1868, after his visit to Sinai, adopted the same view, although he states that he has no decided opinion on the subject owing to the great want of evidence.

Hull ‡ describes them from the head of Wadi Hamr right along to Gebel Dhalâl, but, as he includes the Upper sandstone of the Carboniferous under this heading, his boundaries and the writer's necessarily differ.

These rocks were first met with in Gebel Hammâm Saidna Musa, General Description. where they were capped by a coral reef dipping 8° S. The sandstone dips about 10° S.E. Further north, in the Wadi el Araba, they form a band between the igneous coast-range and the Cretaceous marls, while on the opposite side of El Qâ they are seen forming the floor and part of the sides of Wadi Thaghâdi. Again, at the junction of the sedimentary and igneous rock in Wadi Ferân, they appear and persist right up Wadi Mokateb, ending against the Carboniferous, and sweeping round to Gebel Abu Alaqa, from whence they run northwards as far as Wadi Shellâl, where they are carried down below the surface by the main fault. A small patch is next seen on the north side of El Markhâ, while the main exposure extends from the head of Wadi Ethâl, along the foot and in the cliff of Gebel el Ti as far as Gebel Dhalâl which is the eastern boundary of the area described. North of Wadi Hamr these rocks are seen in the foot of the cliff of El Ti where it is cut out by a fault at Wadi Bagha.

Taking the areas in turn it is now necessary to describe them in Gebel Hammâm Saidna Musa. detail. In Gebel Hammâm Saidna Musa it is a yellow sandstone covered

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\* "Studiî scientifici sull' Egitto," etc., Lucca, 1864.

† Op. cit p. 27.

‡ Op. cit p. 31.

by a Beach deposit and dipping  $5^{\circ}$  S.E. This forms the base of Gebel Wadi el Araba. Abu Suwêra and is continuous with that which appears in Wadi el Araba. Here the sandstone consists of the following members from above :—

*Top.*

1. Red sandstone containing numerous pebbles of quartzite.
2. Purple sandstones.
3. Pure white sandstone.
4. Red or brownish sandstone lying unconformably on igneous rock. These dip at  $10^{\circ}$  to  $15^{\circ}$  to the east.

In the wadi, beds of white and pinkish pebbles are met with which are remains of the weathering of the sandstone, while the sand has been piled up on the flank of the igneous range, this being a direct contradiction to Walther's statement as to the origin of the sand. Further north, where the upper part of the wadi enters the sea through a break in the igneous range due to a dip-fault which has thrown forward the coast-range with the sedimentary rock in proportion, some of the white sandstones which occur in the wadi have become so impregnated with hydro-carbons as to be perfectly black, while the smell is very marked. This sandstone continues up to where the igneous range ends, the rest of it being lost under the gravels in the coast plain.

In Wadi Thaghâdi there occurs a patch of dark red Nubian sandstone which seen from a distance, appears like dark-red igneous rock. It was probably this which made Walther mark it “? granit” in the map which accompanies his “Korallen Riffe der Sinaihalbinsel,” as he could not have been at all in doubt of the nature of the rock had he visited it.

At Wadi Ferân where the gneiss is cut off by the main fault the Nubian sandstone comes in in a wedge-shaped piece; this is due to the vicinity of a node in the fault, the throw being much less than it is further south. In places it is still lying on the flanks of the gneiss as if it had been dragged down from above by the rocks previous to their being fractured.

Wadi Mokateb. On the north side of this wadi, where the other Wadi Mokateb enters it, the sandstone forms a narrow strip dipping from  $5^{\circ}$  to  $7^{\circ}$  west. As the water-parting is reached between the two wadis bearing the name of Mokateb the low hills of the Cretaceous marls suddenly shrink up, the sandstone widening correspondingly; the former presents an extremely narrow outcrop, due perhaps to a sharp fold, for it opens out again further north. As the sandstone outcrop widened the dip became almost nil; further north the inclination is slightly towards the gneiss

hills. The character of the rock is very similar to that in the coast-range of El Araba, it being composed of rather coarse sand containing numerous pebbles of quartzite. Near the top it becomes thin-bedded, and fissile, rather approaching a marl in appearance, while its colour is a pale purplish-pink with darker ferruginous bands. Lower down in the series in Wadi Mokateb, where the numerous fine inscriptions occur, the rock is a dense, dark-red and durable one. From the point where Wadi Sidri leaves the hills the sandstone sweeps round towards Gebel Abu Alaqa where its outcrop suddenly narrows, its dip gradually changing to a southerly direction while in the hill itself it is apparently lying horizontal. Here, as was stated in the previous chapter, there is a difficulty about the junction between this rock and the Carboniferous. It may be that there has been a dome-shaped mass such as appears immediately to the north where the rocks are dipping steeply to the southwest, the Carboniferous rocks in the centre appearing on the same level as those stratigraphically above them. There is no doubt that a fault exists between this formation and the hills, as it is impossible for these rocks to overtop them, and become continuous with those on their eastern slopes.

*Wadi Budra.*—On the north side of Wadi Sidri, the Nubian sandstone is present at the mouth of Wadi Budra as a narrow strip dipping steeply at  $25^{\circ}$  to the west under the Cretaceous marls, while below it come the Carboniferous rocks. As the wadi is followed up, the dip gradually falls to  $10^{\circ}$ , the outcrop at the same time becoming relatively wider, but after passing the Naqb Budra and approaching Wadi Shellal, it is suddenly nipped out by a fault. In this particular area the sandstones are not so compact as in other places, the tendency rather being towards thin-bedding and fissility, with a higher percentage of argillaceous matter and iron, the latter in places being so abundant as to make the rocks a dead-black, thus simulating the appearance of basalt. Just a little distance to the north of Maghara a small rhomboidal piece of these rocks has been let down into the Carboniferous beds by a fault, thus causing the turquoise beds to disappear below ground.

On the north side of El Markhâ there is a small patch of Nubian sandstone brought up by a fault in the middle of the Cretaceous area.

Coming now to the main mass of Nubian rocks which are found in the cliff and along the foot of Gebel el Ti extending from lat.  $28^{\circ} 50' N.$  to  $29^{\circ} 14' N.$ , the place where they were examined in detail was in

Gebel Dhalâl. This hill, which is an off-shoot of Gebel el Ti, consists of the following main divisions measured by aneroid :—

*Top.*

- |   |     |        |
|---|-----|--------|
| 1. Crystalline marly limestone containing small gastropods and a big <i>Nerinea</i> ... | 98  | metres |
| 2. Reddish, slightly argillaceous sandstones  | 80  | "      |
| 3. Pure white sandstone forming the base and foot-hills of Dhalâl                       | 214 | "      |

This white sandstone is of a very dazzling appearance when seen at a distance. It is very friable, strongly false-bedded, and contains a few small lenticles of white quartz pebbles, these being also scattered sporadically through it. On account of its friability it is easily worn away by the wind, and forms steep-sided, rounded knolls which it is dangerous to attempt to climb owing to the readiness with which it crumbles under the foot. Crossing over an area of this rock makes very difficult going for camels, on account of round hollows which have been eddied out by the wind and sand, and also the sudden drops over small waterfalls, etc., which are of frequent occurrence. In this hill are magnificent examples of wind and sand action, the rock being weathered and hollowed out into buttressed scarps of the most fantastic shapes. If this rock were in a more favourable position for transport it would have been a valuable source of sand for the manufacture of glass. Situated as it is the cost of transport would be so great that it would be impossible to make glass from it at a profit.

Following the outcrop of the white sandstone northwards, it seems as it approaches the Wadi Siq, to contract and become lower in the cliff, while the Carboniferous appears to expand correspondingly, this being perhaps due to a roll in the beds. Towards the base of the white sandstone the beds become coarser and more gritty, as if they had been deposited in water not far from land. This has been undoubtedly the case, as the underlying Carboniferous is here very thin, a proximity to land being also suggested by the ripple-marks and false-bedding which are so frequently seen. The reason for the thickening of the Carboniferous is that in going north the observer is going towards the deeper water.

Passing northwards across the Debbet el Ramli the Nubian sandstone occupies the base of El Ti, and extends out into the plain beyond the bed of Wadi Garf. The boundary is here drawn somewhat arbitrarily on account of the amount of blown sand in the plain; it was only by connecting points where the remains of basalt were seen, or the quartzite bed which underlaid it was noted that this could be done.



SAND ACTION IN GEBEL DHALAL.



Further west the outcrop of the sandstone narrows considerably, its boundary running up to the foot of the cliff; the reason for this is not clear, but it is most likely due to a change in the dip, combined with a roll in the beds. This narrow outcrop continues until the head of Wadi Hamr is reached (the most northerly limit of the Carboniferous), when it suddenly opens out into a vast terraced plain, the great extension being due to a reduplication of the beds by the prolongation of the Wadi Nasb fault. In this plain, which is practically the last exposure of these sandstones of any importance, the dip is about  $5^{\circ}$  towards the cliff, with also a gentle inclination westward. Against it, at Sarbût el Gemel, the Cretaceous limestone is let down by the main fault; while farther north the Cretaceous marls are seen lying against this sandstone at an angle varying from  $30^{\circ}$  to  $40^{\circ}$ , being thrown down by an offshoot of the main fault. Further north the fault dies away, and the sandstone dips under the marls in the normal way. It has evidently been a trough which was broken by the fault running along the present edge of the cliff, as when the fault dies away a normal syncline is left.

Along the western edge of the plateau of Abu Dêmat the Nubian sandstone is also exposed by a fault which has let down the overlying limestone against it.

In Wadi Abu Qâda the Nubian Sandstone is exposed on one side by a fault which has let down the overlying marls against it. Further north, along the cliff of El Ti near Wadi Bagha, the Nubian Sandstone is again seen, being exposed by a fault which has let down the marls and the Upper Eocene beds against it.

These beds are remarkably constant in their characters over wide areas, as well as in their total thickness. In describing the section at Gebel Dhalâl it was found that the thickness was 294 metres; while in Section VI, where the dip was measured and the outcrop accurately known, it scales out at 300 metres, the two results thus tallying very closely.

About the origin of this deposit there seems to be a difference of opinion. Walther \* ascribed it to Aeolian action, and Fourtau † in 1898 reiterates this statement, while the majority of earlier writers regard it as of fluvio-marine origin. (The finding of *Inoceramus Cripsii* at Aswan in these rocks by Dr. Ball supports this view). With the latter idea the writer's views coincide; indeed it is difficult to imagine how

Origin of this Sandstone.

\* "Ueb. Ergebn. ein. Forschungsreise auf d. Sinaihalbinsel u. in d. Arab. Wüste." Verhandl. d. Gesell. f. Erdk. z. Berlin, 1888, Bd. XV. N° 6, pp. 244-245.

† Op. cit.

any one could ascribe such an origin as the former to a deposit covering such enormous areas of country. The whole appearance of the rocks is against it; for instead of being a big, unstratified, tumbled mass, as Fourtau says, they are well-bedded, in every place shewing the dip running in a normal fashion. In many places there is strong false-bedding, but that differs in character from the rippling seen in a sand-dune; for whereas in the latter the grains are invariably rounded and highly polished, in the other case they are angular or subangular with a much less degree of polish. The fact that in places there are clayey and marly beds here and there in the series is also against this idea; while the strongest argument against it is the appearance of the sheet of basalt lying between it and the Carboniferous, which has none of the characters of a subaërial flow but has undoubtedly been poured out under water. The latter writer, as well as Walther, includes all the sandstone above the Carboniferous limestone in the Nubian Sandstone, or as he prefers to call it, the Sinaitic sandstone. This being the case, it is difficult to explain the gradual passage between the limestone and sandstone, as also the presence of fossils such as *Lepidodendron*, and the explanation must be left to the supporters of the æolian origin of these rocks.

The age of the Sandstone.

It is difficult to assign a definite age to this mass of sandstones seeing that no fossils have been found in it. Hull \* in his map puts it as (?) Neocomian, Cenomanian, and this is undoubtedly correct as far as it goes. It is known that in the marls which overlie this rock a well-known Cenomanian fossil (*Hemaster cubicus*) occurs. It is therefore probable that the top, at least, of these sandstones is of Cenomanian age, while the other part is Neocomian. No breaks, as far as this formation has been examined, have been noticed, but it is a difficult thing to recognise an unconformability in sandstone where so much false-bedding exists. It is possible that a great thickness of sandstone overlying the lava flow, which is assumed as the upper boundary of the Carboniferous, has been removed during the continental period which undoubtedly existed from Carboniferous to Cretaceous times.

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## SECTION VI.—CARBONIFEROUS ROCKS.

These rocks occupy, on the western side of the Sinai Peninsula, a strip of country extending from the watershed at Gebel Dhalâl, along

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\* Op. cit.

the foot of El Ti as far as the head of Wadi Hamr, from thence running westward until they are cut off by the great fault which has thrown the Cretaceous down against them, and occupying the country as far south as Maghara, and on either side of Wadi Baba. They consist of a thick series of reddish and brownish sandstones underlaid by a bed of limestone, which in turn is underlaid by a series of dark-red sandstones and shales, these resting on the eroded surface of the grey gneiss which forms the country rock. On its upper surface it appears to pass conformably as far as can be seen into the Nubian sandstone series, which in its upper half is known to be of Cenomanian age, but whether this lower part represents the space of time between this period and the Carboniferous it is difficult, in the complete absence of fossils, to say definitely. The writer is, however, inclined to think that, as there is no definite evidence of continuity in the sedimentation, the thickness of sandstone referred to is all of Cretaceous age.

Russeger \* in his maps and papers grouped the whole of the sandstones in Sinai as Lower Cretaceous.

In 1864 Figari Bey † described these rocks and the overlying Nubian sandstone, and assigned them to the Triassic period.

In 1868 Bauerman ‡ visited the peninsula and described the sandstones, etc., lying between the igneous and metamorphic series and the Cretaceous beds. He, however, could not come to any definite conclusion as to the age of these beds, and eventually followed Figari Bey in regarding them as of Triassic age, although he did not feel satisfied with the evidence to hand.

In the following year, the Officers of the Ordnance Survey of Sinai § collected the following fossils from the limestone:—

(S) *Orphis Michelini*, Wadi Nasb.

(S) *Streptorhynchus crenistria*, Phil. Wadi Nasb.

(S) *Spirifer*.

\* *Murchisonia*, Wadi Nasb.

\* *Eulima*. " "

(S) *Rhodocrinus* and *Poteriocrinus*, Wadi Nasb.

\* *Lepidodendron Mosaicum*, Salter. " "

(H) *Sigillaria sp.*, Wadi Mokateb.

(S)=Survey Officers. \*—J. Salters's collection described in Q.J.G.S. No. 97. (H)=The Rev F.W. Holland.

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\* Op. cit.

† Op. cit.

‡ Op. cit.

§ Op. cit.

In 1883 Hull \* visited this place and collected fossils which shewed that the age of the limestone was Lower Carboniferous. He gives the thickness of the bed as 20 feet, but as will be shown later, this is far too little, the reason being that he was dealing with a place where it had been much eroded.

It is to be regretted however that, in the section he gives across Wadis Serabit and Nash, he has turned it round the wrong way. No compass bearing is given indicating the direction of the beds, but as the dip of the beds is north-easterly it is presumed that the line lies north-east—south-west. Accordingly the Debbet el Ramli which is on the right of the section should be on the left as the plain lies to the east of Serabit.

To the sandstones which underlie this limestone, Hull has proposed the name of the "Desert Sandstone" which may perhaps be allowed to stand, although the writer prefers to group it with the limestone under the head of Carboniferous.

He recognises the fact that there are great variations in thickness of these lower beds owing to the irregularity of the floor, only shallow-water types occurring in these areas. During the survey of this area, the observations made enable the writer to endorse these views, and to add that there is evidence of an overlap as well.

Turning now to the detailed description of the rocks it is proposed to work from above downwards. Beginning with the most easterly extension noticed of these rocks, viz., at the head of Wadi el Akhdar, there is a series of thin, gritty, ripple-marked beds, often strongly current-bedded, and dark-red in colour. Further up these beds became lighter coloured, and in the wadi showed fine concentric bands of alternate red and white, the extreme phase of which was the formation of ferruginous nodules with a core of sandstone. These pass upwards by a sharp transition into a pure white, friable sandstone, which has been regarded as Post-Carboniferous for reasons which will be adduced later.

In Wadi Sheqer the base of this sandstone is seen to consist of a conglomerate of quartzite pebbles about the size of walnuts, which is only a little over a metre thick. This is cemented by silica, and is almost a quartzite, while above it the beds are gritty but gradually becoming finer as they are traced upwards, this being in accordance with the supposition that these beds were deposited in a subsiding area. To the north of Wadi Siq these sandstones are seen in better

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\* Op. cit., p. 45.

development, in a small hill—Gebel Habîr—where the following succession from above was noted :—

*Top.*

1. Thin bed of pink siliceous sandstone, (quartzite).
2. Series of redder sandstones.
3. Two thin beds of purplish, fissile sandstones with markings resembling plant-impressions.
4. A whitish sandstone forming the base.

The whole of this section amounted to 144 metres thickness. Further north in Gebel Hameier a cap of olivine basalt covers this sandstone and underneath it comes the thin bed of quartzite noted in the above section. In several other hills beside Habîr this bed of quartzite is present thus evidencing the former presence of the basalt.

In the Debbet el Ramli the floor of the plain is almost entirely composed of the quartzite bed which underlies the basalt. On the edge of the Wadi Baba a much-altered dolerite dyke cuts the sandstone, this being the only instance met with where the dyke cuts the sandstone above the limestone. It is stated in the description of the lava-flows that the basalt has been adopted as the upper boundary of the Carboniferous rocks, and this has been found to be a very useful indicator ; for where it has been removed, the quartzite bed is always present. The reason for the adoption of this bed as the boundary-line is, that in the sandstones underneath the basalt several specimens of *Lepidodendron* were found, while above it not a single specimen was met with. This may be regarded by some as a somewhat arbitrary line, but in the absence of a better it has been found to answer the purpose very well, the boundary lines fitting in over long distances.

As to the thickness of this sandstone it has never been seen in a complete section, but in Section VI, where the height of the hills and the dip of the beds were known, it works out at 150 metres which is very near the mark, 144 metres having been noted in Gebel Habîr where the limestone was not exposed. Working from Gebel el Ti towards the hills round Wadi Baba, the upturned edges of the beds are crossed in descending order, until in the neighbourhood of Wadi Malha the limestone bed is found, the dip being about  $3^{\circ}$  towards El Ti. In Gebel Serabîl el Khâdim the whole series of the Carboniferous is crossed as this hill is climbed. It is capped by the same bed of olivine-basalt as was seen in the hill of Hameier. Beneath it come the same sandstones, the limestone following in descending order, and then the lower series of sandstones, the whole, excluding the igneous rocks, being

estimated to be 350 metres thick. From the head of Wadi Malha this rock occupies the whole of the plain of the Debbet el Ramli up to the head of Wadi Hamr. No limestone is seen outcropping in the plain, it having gone under just as the edge is crossed. In the region of Wadi Hamr, there are splendid examples of wind action on these sandstone rocks; they are planed off and rounded to such an extent that one might be excused if they were mistaken for granite knolls in the distance. At this spot, too, they are much impregnated with iron oxide, thus causing them to assume the peculiar slaggy appearance so common in the Nubian sandstone. Except for small outcrops in the sides of the hills, or where it has been let down by faults, this rock is not found in great force in the neighbourhood of Wadi Baba. In this district, the country has a general trend towards the base of Gebel el Ti, the beds having a general dip of about  $3^{\circ}$  in that direction; while they slope up towards the ridge of El Markhâ, where they have been broken by the great fault which runs up the peninsula more or less parallel to the sea. There is a general fall of the beds to the north, as well as the north-east. In Wadi Nasb the sandstone along with the underlying beds is thrown down by the fault first discovered by Bauerman,\* to the extent of 153 metres. Further north the throw is not so great as in this wadi, the two sandstones being laid against each other.

The next place where this rock occurs is between Wadis Shellâl and Sidri, where the ground is entirely occupied by it and the basalt, except where a small patch of Nubian sandstone has been let in by a fault. In this area occur the old workings for turquoise in Wadi Qena. They are about half-way up the cliff in a light-coloured bed of sandstone, while on the top of the hill is the basalt flow previously mentioned.

The boundary of this sandstone has been drawn arbitrarily to the south as there is no well-marked line between it and the Nubian series. The main reasons for doing so, are:—

1. *Lepidodendron* remains were found in the rock to the north of the boundary while none were seen to the south.
2. These beds were on a lower level than the basalt.
3. True Nubian sandstone overlies them in Gebel Abu Alaqa.

On their southern border, however, there is a difficulty about the suddenness with which they go under the Nubian. This is capable of two explanations viz: (1) A fault may have let them down, or a sudden change of dip such as is seen on the side of Wadi Budra; or (2)

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\* Op. cit.

there may have been an overlap of the younger over the older beds. There is little doubt, however, as to the relative age of the beds on either side of Wadi Sidri, and the boundary cannot be far from the actual junction.

In Wadi Qenaia, a tributary of Qena the turquoise-bearing bed runs quickly to earth and does not show again for a good distance to the north, being let down by a fault as well as by a syncline. This fault which is roughly quadrilateral in outline has let in a small patch of Nubian sandstone undoubtedly carrying down the basalt bed with it, thus accounting for the hiatus in the continuity of the flow which could not otherwise be explained. The whole of this area has been much folded and faulted. Towards the west the hills dip steeply about  $12^{\circ}$ , while northwards they are inclined  $5^{\circ}$ . On the east side they have been let down by the main fault against the granite, the throw being 990 metres. Step-faulting has also been common as slickensides are very abundant. Some of the sandstones in this district are highly charged with iron, being so dark-coloured as to simulate the appearance of the basalt.

On the north along the side of Wadi Shellâl these beds have been let down again by the same fault, which there bends round in a south-westerly direction, the sandstone which is seen at the top of the hill on the opposite side of the wadi being found in its floor.

In Wadi Budra near its mouth these beds are dipping at  $25^{\circ}$  under the Nubian sandstone, while only a little distance to the east of this point the beds are horizontal; it seems therefore that here is the remainder of a large anticline which has been broken at its eastern limb while the other has been left intact. Further north the dip gradually falls to  $10^{\circ}$ , the outcrop of the Nubian sandstone relatively widening.

Along the side of Wadi Shellâl, near where it enters Wadi Baba, and on the line of the main fault, the sandstone has been carried underground, but as the wadi is followed southwards, first Nubian sandstone, then the upper sandstone of the Carboniferous, and finally the limestone appears as the downthrow gradually lessens, until as the branch-fault is followed up, it dies out altogether, the beds assuming their normal position relative to each other.

*Carboniferous limestone.*—This bed is exposed over an area on either side of Wadi Baba measuring 14 by 16 kilometres. It does not actually cover this area but its various outcrops are met with in it, while several large patches actually exist. It was first met at the head of Wadi Malha where the guide had taken the writer to show him a curious black stone

which had excited his curiosity, and which turned out to be a mixture of pyrolusite, psilomelane and hæmatite. After examination, this ore was found to lie in pockets at the base of a dark, crystalline limestone, at its junction with the underlying sandstone. These pockets were from .7 to 1.3 metres deep. (For a fuller account of this ore see section on Economic Products, p. 199). This bed of limestone was traced over the plateau to where the true Wadi Baba begins, a distance of 6 kilometres. In places the limestone is highly impregnated with manganese ores. In the middle of this bed there occurs an ochreous, fissile limestone, which has been worked round the edges of the small knolls on the plateau for copper; numerous workings were seen, but no galleries or tunnels were met with. From what could be seen, the ore (which was malachite) was only in incrustations on the sides of cracks and did not look at all worth working. There seems to be little doubt that this was one of the places whence the ancient Egyptians got the ore which they smelted in Wadi Nasb.

Wadi Meringa.

As it was the hard crystalline bed which forms the base of this series which covered the plateau above referred to, it was difficult to find fossils in it, but near the head of Wadi Meringa a section was found which shewed it to be composed of:—

Top.

1. Bed of crystalline limestone.
2. Layers of fissile, ochreous limestone.
3. Bed of crystalline limestone.

These were in all from 20 to 30 metres thick. In the ochreous beds were found *Zaphrentis*, *Chætetes*, *Spirifer* and *Productus*, thus shewing that it belonged to the Carboniferous period. This limestone also occurs in Gebel Serabît el Khâdim and the hill to the north; in the former it extends for several kilometres on the surface of the plateau to the south-west. From the former hill a beautiful specimen of kidney ore was obtained, while numerous other examples were seen embedded in the rock. In the ridge separating Wadi Lahiân from Wadi Nasb, this bed also occurs, forming the surface and disappearing under the sandstone which forms Gebel Riglên. On the top of the ridge there are 12 to 15 metres of a dark crystalline limestone containing rounded quartz-grains, and highly coloured by iron ores. At this place, wherever the limestone has been removed, the manganese ores are seen, and doubtless they occur beneath it over all the area. Near the junction of the limestone and underlying sandstone, small pockets of very pure hæmatite occur, varying from 3 to 6 kilos. in weight. Along this valley runs the fault first discovered by Bauerman, which throws down

the limestone against the fundamental gneiss, the throw being 153 metres. According to Hull\* the throw is 123 metres; the discrepancy may be due to the different places at which the throw was measured. On the west side of the wadi, i.e., on the down-throw side, there occur, at the base of the limestone, some pockets of manganese and iron ores, and here there was a gallery driven into the rock to work it. At this point are the following members of the series :—

*Top.*

- 1 Limestone full of crinoid stems and a few crinoids.
2. „ with *Spirifer* and *Productus*.
3. „ with *Chaetetes*.
4. Hard, brittle, crystalline limestone.
5. Ochreous, marly beds.
6. Gritty, crystalline limestone.

These were so placed that it was impossible to obtain the thickness of the various beds. The limestone dips east at this point at 5°, the high dip being due to the fault, but there is also a gentle roll north and south, while the rocks dip N.N.W. at 3°. The basal limestone is often so impregnated by the ores of manganese and iron that it becomes black and brown. The *Chaetetes* and brachiopod beds are somewhat fissile but crystalline, while the crinoid bed is a hard crystalline rock.

On the north side of Wadi Baba near the mouth of Nasb there is a good example of the solution of limestone at the junction of these beds with the sandstone.

The fault which throws down the limestone here was traced beyond Wadi Baba to the Debbet el Ramli where further evidence of it was hidden under the sand of the plain.

In Wadi Halliq there are some old mines in the limestone in which manganese and iron ores occur in large quantity, the former largely in the form of wad. It was not for these ores, however, that these mines were opened, as they have been thrown out into the rubble-heaps; the probability is that it was copper, seeing it was the centre of the copper smelting district. To the south of this point the limestone occupies the surface of the plateau—a large patch 7·5 by 3·5 kilometres in extent, and stretching almost up to the granite hills at the head of Wadi Shellâl. Wherever examined, the manganese and iron ores were always found under the limestone.

To the west of Wadi Halliq the limestone occupies the surface of

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\* Op. cit.

the plateau and extends to the edge of the scarp which overlooks the Cretaceous country to the north of El Markhâ, covering an area 7.5 by 5 kilometres.

On the south side of Wadi Baba, on the range between it and Wadi Shellâl, this limestone is found lying at three different levels, due to a series of step-faults culminating in the main-fault line which runs along the bed of the latter wadi, some of them throwing down over 60 metres.

In places near the edge of Baba the limestone forms a steep ridge often not more than 2 metres wide underlaid by the sandstone, and that in turn by the granite. There are two main step faults which throw down the limestone, and these in both instances have formed drainages which end in sheer cliffs before the water reaches the main wadi. In one of the detached pieces of the limestone a good section was found where it was possible to measure the thickness of the beds, the following being the details:—

*Top.*

1. Crystalline limestone with thin bed of grit near the top, the whole representing the first four beds in the Nash Section 15 metres
2. Ochreous Marly beds ... .. 9 „
3. Crystalline limestone ... .. 12 „

From the upper beds were collected many corals (*Zaphrentidæ*) *Crinoid* stems, and *Bryozoa*. In Wadi Shellâl the limestone is again seen. From this exposure Walther collected *Crinoid* stems, *Chaetetes* and *Zaphrentis*. In 1893 Rothpletz\* published a paper on Sinai in which he concludes from the fossils he collected in Wadi Shellâl that these beds were of Permian age. Further up the wadi a dolerite dyke cuts this bed but does not reach the surface.

A comparison of this exposure of Carboniferous limestone with that described by Walther from the Wadi Araba on the west side of the Gulf of Suez, shews the latter to be much thicker and apparently of a deeper water facies as it is richer in brachiopoda, pelecypoda and gastropoda, while in corals only two specimens were obtained; the former on the contrary is richest in corals, and has not yielded any pelecypoda or gastropoda. In thickness that of Wadi Araba is three times that of the Sinai representative. When the thickness of the sandstones above the limestone come to be compared the opposite is the case to what it was with the limestones; for, whereas, Walther only gets 250 metres between the Cretaceous and the Carboniferous, in Sinai there are 150 metres Carboniferous sandstone, and 300 metres more between it and

\* "Stratigraphische von der Sinaihalbinsel" (Neues Jahrb. f. Miner, etc. 1893, Bd. I, pp. 101-104).

the Cretaceous limestones, making in all 450 metres. It would thus seem as though shallower water conditions had prevailed in Sinai, sandstone being deposited there, while limestone was forming in Wadi Araba.

*The Lower sandstone.*—This rock appears underneath the limestone wherever that bed outcrops on the surface. It was first seen in Gebel Serabit el Khâdim, where it consists of a mixture of reddish brown, purple and red shales and sandstones, not so massive and hard as the upper series. In its upper members it is lighter in colour, and in this mountain the ancient Egyptians had worked it for turquoise. The character ascribed to it by Hull, "often conglomeratic or brecciated," was not apparent in Wadi Serabit or Nasb, its composition rather suggesting deeper water conditions than obtained in the upper sandstone. With the thickness given by Hull for this series in Wadi Nasb the writer cannot agree, as in measuring the throw of the fault in that valley the displacement was found to be 153 metres, in which only 15 metres of metamorphic rock were visible. It thus follows that the thickness of the sandstone is 138 metres, and not 46 to 76 metres, as stated by Hull.

At its junction with the overlying limestone it is much impregnated with the oxides of iron and manganese, pockets of these ores, as previously stated, occurring there. No fossils have been obtained from it. As its characters are fairly constant, although occurring over a fairly wide area, no more description is necessary. That it has had a much wider extension in earlier times is certain, as evidenced by its capping the highest hill in the vicinity. It therefore seems probable that it extended a greater distance south in earlier times than at the present day. Before leaving this formation it is necessary to shew the evidence for the overlap which was mentioned at the beginning of this account (p. 156). It was stated that there was a considerable thinning of the Carboniferous beds, as here defined, towards the central watershed, the beds there present representing the upper sandstone. As this formation was followed north and west the sandstone thickened, older and older beds coming in underneath as the old planed-down floor was descended until the limestone beds were found. It would therefore seem that there had been a basin of deepish water extending round by Serabit and Wadi Baba district, in which the water was sufficiently clear to allow of the growth of the crinoids and corals found in the limestone. During the deposition of the limestone, the land which occupied the district of the present central watershed was still above water, but was slowly subsiding, and it was not until after the close

of the limestone deposition, that sandstone and conglomerate began to be formed. It is now necessary to point out a mistake published by Hull in the map which accompanies his memoir, in which he shews his "Desert Sandstone" and limestone to extend in a broad band over the watershed. As this writer has expressly limited the above title to the sandstone underlying the limestone, it is evident from the foregoing remarks that neither of these beds exist there, only the upper sandstone which he classes with the Nubian sandstone being present.

After the close of the limestone period, shallower water conditions seem to have set in. Of this there is evidence in the gritty bed in the upper part of the limestone, and these conditions seem to have persisted after the continental period until about the beginning of Senonian times when a gradual deepening of the water set in, marls followed by limestone being deposited.

As to the age of the lower sandstone some have proposed to regard it as Devonian; but as there is no sign of fossils to prove this, and in the absence of any unconformity between it and the overlying limestone, it is preferred to regard it as belonging to the Lower Carboniferous.

A short résumé of the main points to be noted with reference to the Carboniferous beds can now be given :—

1. The Carboniferous consists of two sandstones, an upper and a lower, separated by a limestone, its upper boundary being marked by a contemporaneous basalt-flow.

2. It has been deposited on the planed-down surface of the gneiss and schist.

3. Towards the central watershed, there is considerable thinning and overlap, the limestone being confined to the deeper water which existed to the west and north.

4. At the junction between the limestone and lower sandstone, pockets of rich manganese and iron ores exist.

5. This formation has undergone a good deal of faulting, being let down by a series of steps until it lies at the foot of the hill-range with the Cretaceous rocks lying against it.

FOSSILS

DETERMINED BY R.B. NEWTON, NATURAL HISTORY MUSEUM, LONDON.

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**Wadi Meringa.**

*Spirifer striatus*, Martin.

Do „ „ var. *attenuatus*, J. de C. Sowerby.

*Reticularia lineata*, Martin sp.

*Orthotetes*? *Crenistria*, Phillips sp.

*Stenopora* sp.

*Zaphrentis* sp. like *Beyrichi*, Rothp.

Do. allied to *Guerangeri*, E. and H.

*Syringopora* like *ramulosa*, Goldf.

**Wadi Nasb.**

*Spirifer convolutus*, Phillips.

Do. *tringonalis*, Martin? var. *crassus*, Koninck.

*Productus*? *scabriculus*, Martin.

*Syringopora* like *ramulosa*, Goldf.

**Wadi Baba.**

*Stenopora* sp.

*Zaphrentis* sp. like *Beyrichi*, Rothp.

*Syringopora* like *ramulosa*, Goldf.

**Gebel Abu Alaqa.**

*Lepidodendron Mosaicum*, Salter.

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SECTION VII.—TECTONIC GEOLOGY OF WESTERN SINAI.

Much has been written on this subject by various writers such as Suess, Walther, Bauerman, Hull, and Rothpletz, by whom the structure of this area, and the origin of the Gulf of Suez, have been fairly well worked out. Of the work of the various observers an excellent compilation has been published by Blanckenhorn,\* who, although he had only visited a small part of this district, has made some very shrewd deductions from the maps at his disposal, in some cases arriving at a more correct conclusion than the author of the map. Thus he points out (what is apparent to any one who has visited the district) that

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\* "Die Strukturlinien Syriens und des Roten Meeres" von Richtofen Festschrift. 1893.

Walther's sections across Qâ Plain do not represent the structure of the country and suggests a fault along the western edge of the plateau to the east of the plain, which is the true interpretation. (See section I.) In his continuation of this fault-line, however, he runs wrong, as it dies out in the vicinity of Wadi Ferân, whereas he connects it with the Gebel Withr fault which begins in this wadi some distance to the west. In his map this writer shows the main-fault running down to Ras Mohammed; but he errs in making the Qâ fault a continuation of it, the latter being a secondary fracture parallel to the former, which runs along the foot of Gebel Serbâl between the sedimentary and igneous rocks. The coast-line fault he draws only as far as the mouth of Wadi Sidri, where he bends it round inland in the direction of Wadi Shellâl making it cut off the Withr fault. In this the writer does not agree with him, as he has traced the coast-fault up to and beyond Gebel Hammâm Farûn, from whence it is continued up as far as Gebel Atâqa where it fuses with the fault which runs along the north side of that range. Of the tectonics of the district to the north of El Markhâ, Blanckenhorn has not been able to collect any information and has nothing to add on the subject. In the following pages therefore it is hoped to throw a good deal of light on the structure of this district and to add some new facts to those already known about this area.

The tectonic geology of this area may be treated under the following heads:—

1. Folds.
2. Faults, divided into Strike-Faults, Step-Faults, Dip-Faults and Trough-Faults.
3. Rifts.

*Folds.*—In Western Sinai two sets of folds are recognisable, the dominant one having its axis lying roughly north-west-south-east parallel to the Gulf of Suez, with a fairly steep dip on either side of the trough, while the axis of the other lies more or less at right angles to the first, and has a much more gentle inclination with its saddles further apart. The dominant set has in every case been broken by faults, which has complicated matters considerably, and caused many observers to arrive at a wrong interpretation of the facts. Describing the folds in detail, the first to be considered is that which has given rise to Qâ Plain with the El Araba range on the west and the sedimentary area composed of Gebels Safaria, Asfar, Thaghadi, Wagraf, El Rigma and Asl or Asfa. As was stated in the chapter on the Cretaceous (p.129) Walther and Fourtau fell into the mistake of supposing that this was a normal fold undis-

turbed by faulting, whereas it will be shown that the syncline has been broken by a line of fracture which has thrown the eastern limb far underground. On the east side the beds lie with a gentle inclination of  $5^{\circ}$  or so to the west, complicated by small puckerings, in which, on the extreme eastern boundary, the dip is very steep on the line of main fracture, at first away from the fault where a sharp V-shaped fold exists, but further on towards the fault, the fracture taking place in the saddle in this case and not in the trough. As stated previously the western limb is formed of Gebel el Araba, and this has not escaped deformation by faulting either, as a glance at the map will shew, the northern half of the range being reduplicated by step-faults. A glance at Section I will shew the relation of the two limbs of the trough after their displacement by faulting. On the west side there is a fair thickness of Miocene limestone which is absent on the east, apparently inclined at  $12^{\circ}$  to the east, while the underlying Eocene and Cretaceous have a dip of about  $22^{\circ}$ , which if it be constant would carry these beds far underground. There is no doubt that a fairly big displacement has taken place, as the Cretaceous limestone on the east has been dragged into an almost vertical position before it broke. The corresponding saddle on the west is represented by the igneous coast range on the north and the ridge of Hammam Saidna Musa and Abu Suwêra, the former of which has lost its cap of sedimentary rock, while the syncline, which in an undisturbed state would have formed the Gulf of Suez, has been broken in its eastern limb as in the previous case, thus producing deep water close in-shore. This fold is continued north beyond the Wadi Ferân where it is broken by two faults hading west, in addition to the main fracture along the edge of the hills. Gebel Withr, which forms the western limb, has been broken by one of the faults, while the low ridge connecting Gebel Mokateb with Abu Alaqa is the result of the other. The idea of a trough is not at first apparent, as it has been filled up with Miocene deposits ; but detailed examination proves it to be so. Section III shews the interpretation of this area.

Beyond Wadi Sidri the synclinal arrangement of the beds is not again apparent until the range of Usêt-Hammam Farûn is reached, some other agency having evidently been at work destroying the continuity of the general line of fold. It may be that at this point there exists a node formed by the crossing of the two sets of folds, which, if it be so, would explain the anomaly. After Wadi Hamr is reached the eastern limb of the trough again becomes apparent, although there is no sign of its corresponding western part, the beds seemingly lying in an uniclinal fold. As soon as Wadi Ethâl is passed, however, the

two limbs appear again and form a regular trough in which lie Newer Tertiary deposits ; while the saddles on either side are broken by lines of fault. Beyond Wadi Gharandel up to near Suez the rocks seem to lie in a unichinal fold, as they dip westward from the cliff of El Ti and never reappear again.

In the case of the second set of folds, as was stated previously it is not nearly so pronounced as the first. It was first noticed at Wadi Ferân where the beds were seen to dip gently on either side of the valley, and it is to this fold that the change of direction of this drainage is due and not to a fault as stated by Walther. The next fold occurs on either side of Wadi Sidri where the marls and gypsum roll gently and cause the south-westerly trend of the drainage.

A south-west-north-east fold in all probability existed where the plain of El Markhâ now is, but being broken by the fault running along the north-east limit of the plain it cannot be recognised, although the inclination of the beds on the north in a southerly direction, and the sudden shift in the direction of the drainage of Wadi Baba point to this conclusion. The next fold is seen in Wadi Hamr and Wadi Tayiba, where the long, gentle slope northwards from the heights to the south is well seen, the drainage following the lowest part of the trough. The fold is not so evident as those to the south, being complicated by the main line of fold which is here again beginning to show. At the mouth of Wadi Tayiba, however, no fold is present ; and its direction has evidently been determined by a line of rift or a crack in the flinty limestones of the Cretaceous. The last of the minor folds is found in Wadi Gharandel and its continuation—Wadi Abu Qâda—where the last indications of this flexure are visible in the Eocene and Cretaceous as they are exposed from under the Newer Tertiaries.

*Faults.*—These are divided into strike-faults, step-faults, dip-faults and trough-faults. Taking the most important first, viz., strike-faults, under this heading is included the great fault which has let down the whole of the coastal region of Western Sinai against the central igneous mass, as well as the secondary fractures more or less parallel with it and the Gulf of Suez, which might be regarded as step-faults if they were closer together. Commencing with the main fault, the first place it was met with was on the east side of the inlier of Gebel Safariat where it was clearly shewn. This fault extends to Ras Mohammed ; although no direct evidence was seen its existence has been inferred. From Gebel Safariat this fracture runs along the foot of the igneous range to Gebel Asfar, Wadi Raqqa being formed along its line, while it

follows the edge of the hills closely, the whole of the Cretaceous and the overlying Eocene being let down below the level of the granite and gneiss hills. Further north, as Wadi Ferân is approached, the Cretaceous limestone, marls, and finally the Nubian sandstone appear on the flanks of the gneiss hills, thus pointing to a diminution of the throw, although this is more apparent than real, as the overlying rocks have been carried away by a side drainage, and if replaced would continue the plateau as seen to the south. Crossing the valley of Ferân with its shallow syncline, this fault is continued along the foot of the hills, the Nubian sandstone only being present, and this continues until Wadi Sidri is crossed, when the Carboniferous sandstone is met with. Here an increase in throw takes place, the lower part of this series lying on the top of Gebel Atâtâr el Dhâmi while the upper part lies at the foot. In places the basalt, which has been adopted as the top of the Carboniferous, lies against the granite which rises from it in a sheer wall and runs as a narrow ridge between the faulted and normally placed sandstones as far as Wadi Shellâl, likewise occupying its north side for some distance. At Wadi Shellâl, for some reason which is not apparent, this fault suddenly changes its direction to S.W.-N.E., the wadi evidently following its line for a time, while short step-faults between Wadi Baba and this valley running more or less parallel to the original line of main fault are cut off by it. From the point where the Shellâl drainage bends round to the north-west to meet that of Baba the main fault returns to its original direction, the former valley and it being coincident; while it may also be regarded as the last of the series of step-faults by which the Carboniferous rocks have been thrown below ground at this place. At this point also, it is joined by the fault which is the continuation of the Gebel Withr fracture. Round the junction of Shellâl and Baba drainages the Cretaceous beds (part of which are only visible) are tilted at  $60^{\circ}$  to the west, a fairly great throw having taken place, (see Section VI). From the mouth of Wadi Baba the fault-line passes between the sedimentary patch and the gneiss range of Gebel Samra, crosses the edge of El Markhâ plain in a northerly direction, and lets down the big mass of Cretaceous rocks which lies to the north of the plain, below the level of the base of the Carboniferous sandstone; while as it is followed north the throw gradually lessens until at Wadi Hamr the Cretaceous limestone is resting against the Nubian sandstone. Here the Tertiary rocks of Sarbût el Gemel cap the lower member of the Cretaceous limestone. Passing north towards Wadi Ethâl the basal limestone of the Cretaceous (*Gryphæa vesicularis* bed) is seen to be thrown down against the Nubian sandstone in the plateau of Gebel Abu Demat. On crossing this wadi

it is found that the hade has changed to the east, the Eocene rocks being let down against the Cretaceous marls. This is an anomaly which is not easily accounted for, unless it be that the dip-fault which exists in Wadi Ethâl has influenced the main fracture and caused it to alter its hade. The other alternative of an inverted fault does not seem to be possible as there is no evidence on which to base such a theory. It seems rather to be connected with the dip-faults; for in Wadi Abu Qâda, where another of these fractures is met with the hade again returns to its normal westerly direction. From this place the line is north-east and 8 kilometres further on it is joined by a secondary line of fault which lets down the Cretaceous marls at the foot of El Ti, while 3 kilometres further another parallel fracture to the east is cut off by this main fault, which here throws down the Bartonian against the Cretaceous marls. Followed northwards the Middle Eocene is seen to be let down against the Nubian sandstone near the Wadi Bagha. Beyond this valley the fault seems to die out and be replaced by a fold as the Middle Eocene gradually rises up over the marls on which it apparently lies unconformably.

*Throw.*—The amount of displacement along this line of fracture is not always easy to estimate, as sections are seldom available for this purpose. It may be taken for granted, however, that the sedimentary rocks, (the Carboniferous, Nubian sandstone, etc.,) covered the whole of the hills of the Sinai Peninsula. In support of this view it may be pointed out that even if it be assumed that the dip of the older beds was gradually lessening, they would easily overtop Gebel Serbâl and even Gebel Um Shomer; the similarity of the beds in El Ti, and those on the west side of the hills, the presence of Carboniferous rocks faulted down, and eventually the continuity of the beds to the north, all go to prove the above assumption. Leaving out of count the Carboniferous of which none has been discovered above ground south of Wadi Ferân, and taking the base of the Nubian sandstone as the starting point of calculation which is nearly 300 metres below ground at Gebel Asfar, the throw here is 1770 metres. Again at the foot of the range of which Atâtâr el Dhami is a peak, a displacement has taken place of 1320 metres; while at the junction of Wadis Shellâl and Baba there is a throw of at least 1030 metres. Further north the mass of Cretaceous lying to the north of El Markhâ has been let down 1320 metres. Beyond this the throw becomes less and less until the fault dies out.

*Secondary faults.*—The first of these is met with, as in the case of the main fault, at Gebel Safariat, and is continued up to the east side of Qâ plain, having broken the syncline and thrown down the Eocene and Cretaceous rocks far beneath the surface of the ground. This fault has caused a steep tilting of the beds on its upthrow side and dies out as it nears Wadi Ferân. In Gebel Safariat itself, one or two small faults occur hading west, by which the Cretaceous limestone is let down against the marls; these run in a northerly direction. At right angles to them are two others which reduplicate the marls. Parallel to the line of fracture which runs up the east of Qâ plain is another which runs behind the limestone hills, but hades to the east, this is, however, a fault of no importance. A small fault also occurs on the west of Wadis Thaghadi and Abu Gurdi by which the Eocene is let down against the Cretaceous marls to the east.

Further north on the side of Ferân two more faults occur hading east, part of them being concerned in a trough-fault. The more westerly of the two throws down the Cretaceous limestone against the marls; while the other lets down the Eocene and Cretaceous limestone partly against the marls, and partly against the *Gryphæa vesicularis* bed. The former of the two crosses the wadi and reduplicates the marls, dying out about the head of Wadi Mokateb.

On the other side of Qâ plain in the El Araba range, several faults occur in its northern half; but all belong to the class of Step-faults, except one which reduplicates the outcrop of the Miocene and hades west. Passing on to Gebel Qabeliat a fault is found running along its seaward side by which the Cretaceous and nummulitic rocks are thrown down against the Nubian sandstone and marls. This is continued across the Wadi Ferân and throws down the Eocene of Khadêd el Dhib and the Beach deposits against the Cretaceous marls, and continues north as far as the mouth of Wadi Sidri where it bends inland to join the main fault at Wadi Shellâl. There is another fracture to the east of this and parallel to it, which is designated the Gebel Withr fault, and begins on Gebel Withr. the north side of Ferân, throwing down the Cretaceous limestone of this range against the gypsumised marls of this formation, and joining the western fault at the mouth of Wadi Sidri. On the other side of the Miocene area there is another line of fracture by which the Cretaceous and Eocene limestones are thrown down to the west against the marls, while to the north the Miocene of Gebel Abu Alaqa is let down against the marls and Nubian sandstone. To the east of this hill a small fault hading east throws down the Carboniferous sandstone. (Section III shews the relation of these faults to each other.)

On the north side of Wadi Sidri a small fault lets down the Sandstone to the east; connected with this are two short faults hading towards each other and more or less at right angles to the first, which let a patch of Nubian sandstone into the Carboniferous.

Gebel Markhâ. To the north of El Markhâ in Gebel Markhâ another small fault is seen, by which the Cretaceous limestone is thrown down to the west against the Nubian sandstone.

Wadi Tayiba. On the south side of Wadi Tayiba there is a small fault by which the flint conglomerate with interbedded lava has been let down to the east against the Cretaceous limestone.

Wadi Nasb. Further to the east in Wadi Nasb a fault hading west throws down the Carboniferous limestone below the base of the underlying sandstone, a distance of 150 metres. This fault at its origin to the south takes part in a trough-fault by which a patch of basalt is let into the Carboniferous. It runs in a north-westerly direction across the Debbet el Ramli until it strikes the cliff of El Ti at Gebel Agrab, where it throws down the Nubian sandstone, and further north just before it dies out, the *Gryphæa vesicularis* bed against the sandstone.

Further north in Wadi Wûta a small fault lets down the Cretaceous marls to the east against the Nubian sandstone. Further east on the other side of the dip-fault which follows the Wadi Abu Qâda, two parallel faults hading west reduplicate the marls, and are finally cut off by the main fault.

Gebel Abiad. To the west of Gebel Abiad and Sanafa, a fault bearing N.E. and N.W. has reduplicated the Middle Eocene, in places bringing it against the Cretaceous limestone.

At the mouth of Wadi Usêt a fault has thrown down the limestone in Hammam Farûn thus producing a low secondary ridge on the sea coast.

In Gebel Dhalâl in El Ti, a small strike-fault lets down the Cretaceous marls against the Nubian sandstone.

*Step-faults.*—Following the rule in the previous descriptions of starting from the south, the first to be noticed are those occurring to the north of the dip-fault in Gebel el Araba. Here the Eocene limestone was found at four different levels thus indicating 3 step-faults, of which the displacements are as follows:—between the most westerly and the next, 48 metres; between this and the next 30 metres; while between the last and the cliff there was 102 metres. These faults must have taken place after the deposition of the Miocene, as it has been carried down by them.

The next place where these are met with is at the mouth of Wadi <sup>Gebel Baba.</sup> Baba in Gebel Baba, where the Carboniferous limestone which occupies the top of the ridge is let down by three steps, the main fault being regarded as the third, until it is found in the bed of Wadi Shellâl. Parallel with these is another which brings down the Nubian sandstone and cuts off the Carboniferous limestone in Wadi Malagan, a tributary of Wadi Shellâl.

*Dip-faults.*—The first to be noticed is that which runs along the south end of Gebel Hammâm Saidna Musa up which the warm springs rise. Although no external evidence exists to prove this fault, still it may be deduced first, from the fact that a line of warm springs rises at the foot of the ridge, and second, the sudden ending of a hill range in a steep escarpment on a flat level plain, which is not the work of denudation.

The next, which is a typical instance of a fault of this kind, occurs half-way up Gebel el Araba, where the coast range of igneous hills is breached by Wadi el Araba. Here the outcrop of the beds is shifted 3·5 kilometres to the west, while the beds are tilted, twisted, and torn in a wonderful manner.

On the east side of Qâ plain and to the south of Gebel Asfa, a fault occurs which by direction belongs to this category, but behaves more like a strike-fault, in that it throws down one bed against another without any shift in the outcrop.

In Wadi Ethâl near its head, a short fault occurs which brings the <sup>Wadi Ethâl.</sup> Nubian sandstone against the Cretaceous limestone, and also changes the hade of the main fault. Further north in Wadi Abu Qâda, another fault has shifted the outcrop of the beds one kilometre to the west, at the same time bringing the hade of the main fault back to the west. On either side of this fault the strike-faults hade in opposite directions thus showing that they were produced concurrently, for had one been prior to the other, the hade of the latter would have been in the same direction right through, there being no disturbing influence to cause a change.

*Trough-faults.*—Very few of this kind of fracture occur in this area. The first occurs in Gebel Maghara where a patch of Nubian sandstone is let into the Carboniferous thus cutting out the turquoise-bearing beds.

To the north of this last patch, an area of basalt has been let into the Carboniferous, the Wadi Nasb fault acting as one of the components of the fracture, while another forms a "V" with it and produces the fault, (see section VI.)

*Rift valleys.*—The only line of valleys which can be safely attributed to "rift" is that which, commencing to the north of Wadi Baba, passes through Wadi Suwiq, over the parting into Wadi Khamila, across Wadi Siq up Wadi Barq into Wadi Lebwa and Barra, across Wadi el Akhdar, through Wadi Solêf into El Sheikh, up Wadi Sahab and across the plateau to Naqb el Hawa into El Raha near Gebel Musa. This is a remarkable line of valleys which it would be difficult to explain otherwise seeing that it lies parallel to the Gulf of Suez and in all probability owes its origin to the same causes. Another remarkable line which lies fairly parallel with the first is that which, commencing at Wadi Siq, runs up the Wadi Entish and Shêqer, through Wadi Hemeier and Harqus, across the plateau to El Watia where it enters El Sheikh which it follows to its head.

M. Raboisson \* has called attention to the peculiar network arrangement of the valleys in Western Sinai. These lines of rifts are accountable for some of those lying N.W.-S.E.; while the lines of fold give rise to the others. The east and west drainages generally are formed along lines of east-and-west folds; while for the S.W.-N.E. drainages it is difficult to give any explanation, unless it is that they are lines of weakness parallel to the rifts on the eastern side of the peninsula and produced by the same forces which have been at work there.

*The age of the rift of the Gulf of Suez.*—This has been discussed to a certain extent in the "Report on the Topography and Geology of the Eastern Desert of Egypt, 1902, p. 214, in the chapter devoted to "Faults and Folding." In it the probable course of the coast-line fault on the Sinai side has been sketched out, and the age of the rift discussed as far as could be done with the information then available. To recapitulate. Blanckenhorn † following Neumayr, assigns the age of Middle Pliocene to the formation of the Red Sea rift on account of the association of a few Red Sea shells with Mediterranean ones in the Clypeaster sands near Giza Pyramids which Neumayr recognises as Middle Pliocene. From the work done on the west side of the gulf it has been shown in the above Report that a few Pliocene fossils associated with Miocene have been found in the reefs and beach deposits there.

From observations made on the Sinai side of the Gulf of Suez, it is

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\* "Explor. géol. dans la pénins. sinaïtique," 1900, Bull. de l'Institut Égyptien.

† Op. cit.

now possible to add some additional information to that already existing concerning the origin of this arm of the Red Sea. Before doing so, however, it would be well to give a general outline of the history of this sea-arm, as far as can be gathered from observations on both sides of the present gulf. Previous to the Miocene period this area (except for the small piece of land at Wadi Tayiba where there is a little Oligocene) appears to have been a land surface. Only a few patches of Upper Eocene are known on the Sinai side, and except for the place already mentioned, no Oligocene has been discovered. This may be due to the fact that the base of the Miocene is not visible in many cases further to the north, as in every case on the Egyptian side of the Isthmus of Suez, the Oligocene sands and gravels are seen beneath the Miocene beds. At the close of the Oligocene period or during Lower Miocene times, during which denudation seems to have been very active, there was a subsidence of the whole area including the Isthmus of Suez and the district between Cairo and Suez along a line joining Gebel Atâqa and Gebel Tura, as well as the district between the former range and the northern Gallâla, and the area extending from the foot of the present Red Sea hills to the plateau of El Ti and the igneous hills of the Sinai Peninsula as far south as the latitude of Abu Shâr. Into this depression the waters of the Mediterranean came, and the deposition of the Middle Miocene rocks was begun.

That the Gulf of Suez was an arm of the Mediterranean at that time is proved by the fauna of the Miocene having affinities with the fauna of that sea, and none with that of the Indian Ocean. This shows the Gulf of Suez to have been in existence before the Red Sea, as if they had existed simultaneously there would have been an admixture of Mediterranean and Erythræan species.

After the close of the Miocene period, there was a re-elevation of the area under discussion; the sea retreated, except perhaps in the lowest part of the trough; denudation took place; and the Upper Miocene beds (if ever present) were removed, during the continued rise of the land. Subsequently, towards the close of Upper Pliocene times, the strain on the beds caused by the upward movement became so great, that they gave way along a N.W.-S.E. line on either side, along the edge of what is now the igneous and sedimentary ranges of the Red Sea hills and the Sinai Peninsula thus forming the Gulf and Isthmus of Suez. Parallel to these main lines of fracture were the secondary ones which bound the Gulf of Suez as it exists at the present day.

Before these secondary fractures took place the land subsided; the

Red Sea, which had by this time come into existence, invaded the depression and the Beach deposits containing Erythæran genera and species began to be deposited. It is after this that the faults which bound the present gulf began to be marked, this being proved by the presence of raised beaches at different levels along the flanks of the hills on the Sinai side. This fact goes to show that the faults on either side of the Gulf of Suez are not synchronous, but that the eastern ones are the older, the series of beaches on the west side showing a gradual rise for a time after the actual fracture took place on the Sinai side.

At the close of the Pliocene or the beginning of Pleistocene times there must have been, not only a submergence of the sedimentary area, but if the deduction of Dr. Hume and the author be correct, a considerable part of the igneous hills underwent submergence as well. During this period were deposited the Pleistocene beach deposits on the hillsides, the brackish water beds of El Qâ, and the conglomerates, etc., found high up the sides and in the beds of the wadis.

As was stated in the "Report on the Topography and Geology of the Eastern Desert," 1902, p. 213, the fault by which the Red Sea was formed is older than those bounding the present Gulf of Suez. It is probable that before the subsidence of the land admitted the waters of the Red Sea there was a comparatively broad belt of land connecting Sinai with Egypt at the place now occupied by Jubal Straits, having deep water close inshore such as exists to-day at Ras Mohammed. Later on, after the Red Sea had submerged the whole area and Pleistocene beds had been deposited, the two faults which bound the present gulf were formed. It thus follows that although geologically the Gulf of Suez was in existence before the Red Sea, in point of age the fractures bounding the former are younger than those which produced the latter.

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## SECTION VIII.—IGNEOUS AND METAMORPHIC ROCKS.

Although no detailed description of these rocks has, as yet, been given by anyone, they have been examined and described in various places by different observers.

Russeger\* has mapped them generally as syenite, diorite and porphyry. He was of opinion that the sandstone in Wadi Nasb and in various other places was pierced by these various rocks.

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\* Op. cit.

Bauerman \* describes the igneous and metamorphic rocks in the area between Wadis Baba, Suwîq, Khamîla, Um Agraf, and Sidri. He recognises the fact of the younger age of the sandstones as compared with the granites and gneisses, the former lying unconformably on the latter. He, however, calls attention to a basic dyke in Wadi Suwîq which pierces the sandstone but does not allow this fact to hinder him from arriving at the true state of things. In 1871, there was published in the "Ordnance Survey of the Peninsula of Sinai," Vol. I, an account of the geology of this district by the Rev. F. W. Holland. He states that out of several hundred specimens collected he only found two or three of true granite. The main rock in the peninsula he describes as a syenite. (In this description the old unrestricted definition of "syenite" must have been used, viz., a rock of similar characters to that found at Syene in the First Cataract, Aswan). In the section across the peninsula the author makes the gneiss and other metamorphic rocks rest on the syenite, and does not show any intrusions from the latter into it. He thus apparently favours the view, although he states his inability to substantiate it, that the gneiss is younger than the granite.

Walther † describes in a general way the rocks seen by him in his trip to Ras Mohammed, and also up Wadi Hebrân, and down Wadi el Sheikh and Ferân. He favours the view that the granites and metamorphic rocks are older than the sandstone and shows this to be so at the mouth of Wadi Shellâl. He, however, states that the Nubian sandstone is cut by a basalt intrusion in the coast-range of El Araba. This example was examined by the present writer, but the evidence seemed rather against the intrusion theory, as no indubitable proofs of alteration by contact were visible. The appearance of the rocks was all in favour of the sandstone being laid unconformably against a basalt knoll.

In 1900, M. Raboisson ‡ gave an account of his journey to Mount Sinai and back in which, after giving a résumé of the work of the various observers on the tectonics of the Jordan Valley, Dead Sea, and Wadi Araba, he attacks M. Lartet's views about the relative age of the Nubian sandstone and the granite and metamorphic rocks. The latter was of opinion that the sandstone was subsequent to the granite, etc., and was not altered by it in any way. The former, however, attacks this view and adduces what he considers indubitable evidence to prove the con-

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\* Op. cit.

† Op. cit.

‡ Op. cit.

trary. He was, however, unfortunate in his choice of a place from which to prove his point. Gebel Abu Alaqa is, as it is described by the Ordnance Survey, Nubian sandstone resting on granite, but not altered in the least. There is not the smallest evidence of contact metamorphism, but at this particular point it is rather a typical piece of sandstone lying unconformably against the granite. In other places, this author also sees the "auréole métamorphique" where the sandstones show alteration by contact with the igneous rocks. He finally concludes that the porphyries have not penetrated the sandstone in the form of veins, but that the granites have passed into the sandstone and altered them. He says that the porphyries, in some cases, have not cut the sandstones by veins, but that fragments of porphyry of widely different size, angular and rolled, have been intimately mixed with the sandstone on the intrusion of the igneous rocks.

Having given a résumé of the views of the different observers in this district, it is now necessary to describe the different occurrences of the various rocks in detail. They will be taken in order of basicity, beginning with the most acid granites.

The rocks may be divided into the following groups:—

(I) *Igneous rocks.*

1. Granites.
2. Syenites and diorites.
3. Dykes and veins.
4. Lava flows.
5. Volcanic necks.

(II) *Metamorphic rocks.*

1. Gneisses and schists.
2. Metamorphic limestones, garnetiferous schists and altered sandstone.

In the first group three divisions can be recognised, viz :

- a) Coarse red granite poor in mica and ferromagnesian constituents.
- b) Porphyritic pink granite containing beautiful crystals of orthoclase.
- c) Grey biotite-granite which passes locally into gneisses, furnishing the material from which all the gneisses and schists have been derived.

The second group comprises the rocks forming a few isolated bosses in the large plateau to the north of Wadi el Akhdar and Wadi Ferân, and also in Wadi Meâr and Um Laha.

In the third group are included the felsitic and doleritic dykes and veins which cut the granites and gneisses in various directions; while

in the fourth group come the contemporaneous flows seen near Maghara, Serabit el Khâdim, Debbet el Ramli, and at Wadi Tayiba, and the altered acid series on the side of Wadi Khashaba. In the fifth group come the doleritic plugs of Gebels Sawasia, Madsûs, Um Iswad, Mareia, and Samr el Tinia or Qasr Abbas Pasha, and the injected fissures connecting them. The first group of the second class includes the strip of altered rocks stretching from Gebel Madsûs to Wadi Um Agra; while the second group contains isolated patches of rocks situated in Gebel Matak el Barûd near the head of Wadi Hebran and in Gebel Um Isnân in Wadi Solâf.

The igneous and metamorphic rocks may be said to extend roughly from lat.  $27^{\circ}45'$  N. to  $29^{\circ}9'$  N. This does not include the small flow in Wadi Tayiba, or the dykes which cut the sedimentary rocks to the north of this boundary. On the western side of the peninsula they may be said, with the exception of the chain of El Araba, to be bounded by the great north-west-south-east fault which separates them from the sedimentaries, and further south by the plain of El Qâ; on the south by the Red Sea; and on the north and north-east by the Carboniferous sandstone and the Debbet el Ramli.

In describing these rocks in detail the order of the above list will be followed.

## I. IGNEOUS ROCKS.

1a. *Coarse red granite*.—Beginning with the most southerly extension of the peninsula, the red granite is first met with in Gebel Um Malaqa. It is to be noted that the granite here differs considerably in character from that found further north, as well as in the Eastern Desert on the western shore of the Gulf of Suez, and approaches more closely to that occurring in the First Cataract at Aswan. The main points of divergence from the common type in this region, are the greater proportion of porphyritic feldspars in comparison to the quartz, the presence of a larger quantity of biotite and hornblende, and the marked difference in the style of weathering; for whereas, in the typical coarse red granite of this area, the tendency is to weather into sharp jagged peaks and ridges towering up above its congeners, the type here present tends to the production of rounded hills and domes, approaching in this characteristic the porphyritic pink granite which is found further to the north, and resembling the Aswan granite very closely in its behaviour. There is no doubt, however, that this rock is only an extreme type of the normal coarse red granite, and is younger

The extent of  
the Igneous  
and Metamor-  
phic Rocks.

Gebel Um  
Malaqa.

than the pink porphyritic variety which it resembles so closely in some of its characters. To the south of Wadi Um Malaqa, this rock is found intruded in the complex of andesitic dolerite, diorite-quartz-felsite, and fine-grained granite which forms Gebel Ât el Gharbi. On the sides of this wadi coarse hornblende-granite is found cutting the grey granite in the foothills, the whole being dyked by dolerite, while in Gebel Um Malaqa itself red granite assumes complete sway. Out in the coast-plain several isolated knolls of this granite (also called Gebel Um Malaqa) rise up through the sand and boulders of the recent deposits like islands in a sea.

Gebel Sakhara,  
Abu Markh, etc.

Further to the north in the main range Gebel Sakhara, and Gebel Abu Markh near their summits are composed of the same rock; while to the east in the foothills, Gebel Motalla and Gebel Um Gatih, and the two isolated masses in the plain, Gebel Hemcrat, and Gebel Masraia, are likewise of red granite, the latter hill being cut by broad dykes of dolerite and quartz-felsite having a general bearing south-west-north-east. The latter rock also contains basic patches (segregation-patches).

Gebel Rashid  
Khanasir, etc.

To the north of Abu Markh the main hill-mass consists of the same type of rock streaked with dykes and veins of dolerite and quartz-felsite, the lower foothills which bear the name of Gebel Mokateb not differing in any way from it. In Gebel Rashid are many dykes of dolerite and quartz-felsite, the former weathering into a soft greenish mass. At the point where Wadi Rashid opens towards the plain are two isolated masses bearing the name of Gebel Khanasir, also composed of red granite and much dyked by dolerite and quartz-felsite.

Gebel Tihî,  
Marit, and  
Um Hash.

To the north of Gebel Rashid comes the hill-mass composed of the peaks of Gebel Tihî, Marit, and Um Hash, all consisting of the same type of red granite, streaked with intercrossing dykes and veins of dolerite and quartz-felsite having the same general direction as previously. On the top of one of the peaks of Gebel Tihî a small wedge of sandstone was found enclosed in the granite, altered almost to a quartzite. This must be a last remnant of a very ancient sedimentary series which at one time covered these rocks, and which must be older than the Carboniferous, as the latter rocks are found resting unaltered on the eroded surface of the granite further north.

Sandstone in  
Granite.

The outlying hills in the plain consist of the same rock, and are much cut by dykes of fine-grained dolerite, and coarse quartz-felsite with porphyritic feldspars; the dykes of the latter rock are often about 3 metres wide and sometimes form compound dykes with the former, their bearing being the same as that of those already described.





DYKE HILL OF GARN ATUD IN COAST PLAIN.

Beyond Wadi Um Hash there extends a mass of hills forming the watershed, of which the principal peaks are Gebels Um Sidri, Temân, and Temalli; while a subsidiary range to the east of Um Sidri is formed by Gebel Um Rieh. There seems to be a fault between this hill and the main range, as the drainage instead of flowing west to the plain collects from both sides in a longitudinal valley lying north and south and finds its way out to the north and south. While in Gebel Um Rieh the two classes of dykes are fairly numerous, further to the north in Gebel Temalli they are much fewer in number and appear to be dying out, only a few stragglers of quartz-felsite being seen.

Gebel Um Sidri, Um Rieh, Teman, and Temalli.

On the summit of the foothills of Gebel Temalli a small patch of Pleistocene sandstone was met with 424 metres above the sea.

Recent sandstone on hills.

Lying out in the plain about 3 kilometres from the main mass of the hills is a remarkable double-peaked knoll with precipitous sides called Gran Atûd, which consists of coarse red granite.

Gran Atûd.

Beyond Wadi Isla at the south side of Wadi Emlaha the red granite ceases to occupy the whole of the hills; it sweeps away in a north-easterly direction towards Gebel Emlaha and Um Shomer where it forms all the higher peaks, again bending back in a north-westerly direction towards Wadi Shiddiq, the lower hills being composed of grey granite or quartz-diorite, into which the former rock is intruded. The boundary of the red granite to the north is the base of the ridge composed of Gebel Wigrân and Giddet el Êla, where it comes up through the grey variety; it then sweeps across the plateau of Fersh Abu Loz, and runs along the eastern side of the dolerite ridge of Koli and Um Iswad to the watershed range of which Um Shomer and Abu Shêqer form prominent peaks. This area is veined and dyked by quartz-felsite and dolerite in some places (as in Gebel Giddet el Êla) so much so that the dykes form half the rock and are such a prominent feature that this hill has derived its name from them.

Gebel Um Shomer, Gebel Shiddiq.

In Wadi Ilti red granite is found cutting the grey biotite granite which here forms the country rock; while in Gebel Sawasia (Ilti of Ordnance Survey) it also occurs, being in turn cut by the doleritic neck which forms the summit of this hill.

Wadi Ilti. Gebel Sawasia.

In Wadi Meâr opposite Gebel Madsûs this granite again appears intruded in the grey granite, and also in Wadi Khrêta which is the continuation of Meâr.

The large plateau-like mass of Gebel Um Sâ, extending to Gebel Gharba, as well as Gebel Watia, El Elwi, and the mountains composing the Sinai massif are all composed of the true red granite as it is known from the Eastern Desert. In this massif occurs the doleritic neck and

Gebel Um Sâ, Gharba, Watia, El Elwi, and Sinai massif.

injected fissure of Gebel Samr el Tinia or Qasr Abbas Pasha, so named from the ruins of a summer palace built by this khedive on its summit.

Gebel Serbâl.

The next place where red granite is found occupying a commanding position, is in the range of Serbâl where it forms the jagged ridges and peaks so characteristic of this mountain. Gebel Bêdhat Um Takha, the most southerly point, and Gebel Um Lahm, the most northerly of the range, are also composed of this granite. This mountain seems to have risen on the boundary-line between the pink porphyritic variety and the grey, the latter apparently being sheared and converted into gneiss, while the former was left unaltered. An important point about this range is, that its axis lies roughly parallel with the north-west-south-east line of the valleys which belong undoubtedly to the class of "Rift Valley." The next mass of red granite in point of latitude is an irregular patch measuring 17·5 by 16 kilometres. It begins near the mouth of the Wadi el Akhdar, forming here a steep-sided plateau called Gebel

Gebel Yenna.

Yenna which abuts on Gebel Goze and El Banât, these latter completing its west and north-west sides. In this rock occur large intrusions of a syenite-felsite; while cutting both are a number of thin dykes and veins of a glassy and spherulitic felsite or felsophyre. This plateau is

Gebel Retema,  
and Hamra.

continued on into Gebel Retema and Hamra, forming the high red mass which borders Wadi Barra on either side, and then stretches away towards the head of Wadi Shêqer, where it gives place to the grey granite and metamorphic rocks which form the country to the north. Round the mouth of Wadi Barra this granite cuts through the pink and grey varieties and stands out in a striking manner from them. To the north of the water-parting between Wadi Barra and Wadi Lebwa, this rock forms a wide plain which is drained by the latter wadi; it forms a small ridge which separates the basin of Wadi Rahaba from Lebwa, but is eventually breached by the latter where it discharges its water into Wadi Aqr. On the other side of this ridge the grey granite forms the open country drained by Wadi Rahaba. At the mouth of Wadi Lebwa the red granite is replaced by the metamorphic series into which it sends intrusions.

Wadi Barra  
and Lebwa.

Dykes.

Near the head of Wadi Aqr the granite is cut by dolerite or diabase dykes 6 to 9 metres wide running in a south-west-north-east direction, while some quartz-felsites also cut it, having the same orientation. In Wadi Lebwa and Barra on the other hand, the dykes seem to cross each other at right angles, the quartz-felsites running in a south-east-north-west direction.

Wadi Nisrin  
and Rumâna.

At the corner of the plateau of grey granite which occupies the country to the north of Wadi Rumâna there appears a mass of fine-

grained red granite lying between this wadi and that of Nisrin. It forms an irregular patch measuring 6·5 by 4·5 kilometres at its greatest length and breadth. This rock is intrusive in the grey granite which forms the main plateau extending from Wadi Rumâna up to Wadi Siq. On the top of this mass was found a small patch of spherulitic felsite of which the relations to the underlying rock could not be determined; it is, however, very probable, that it is the remains of a small sheet or vein of the same magma from which the dykes and veins met with in the granite of Gebel Yenna were injected. Cutting both the granites, is a dyke of porphyritic dolerite 4 metres wide, in which occur feldspars measuring 8 by 2·5 millimetres, while they are also seen to form "glomero-porphyrific" patches; calcite is also present in places. Some small dykes weather out very readily, forming narrow gullies down which the water makes its way, often ending in a precipitous face over which it is impossible to descend. The tendency of this red granite is to form sharp ridges; and in the watercourses steep and polished waterfalls, over which it is dangerous to travel, while lower down, the valleys are filled with huge boulders, mixed with a fair amount of disintegrated rock, which in spring supports a luxuriant crop of "hamada" a succulent plant much relished by camels.

The only other place where the red granite appears is in Gebel Abu ElAraba range. Darba, a high conical hill in the granite range of El Araba extending down the coast of the Gulf of Suez, from the mouth of the Wadi Ferân to Gebel Abu Suwêra. It occurs all through the range intruded into the pink variety and the granophyre which form the main mass of the range, the whole being dyked and veined in a marvellous manner by dolerite which seems to follow lines of flexure.

1b. *Pink porphyritic granite.*—This rock is characterised, as its name implies, by its pink colour, its possessing large pink orthoclase feldspars which give a striking appearance to it, and by a much smaller proportion of quartz than that which the previous type of granite contains. Its mode of weathering is also quite different; for whereas, in the red granite the tendency is to form sharp, jagged peaks, and narrow ridges, this rock tends rather to the formation of flat, rounded domes, and low rolling bluffs, which, when seen from above, suggest the "roches moutonnées" of the French geologists. It differs also from the previous rock in its tendency to scale off in thin sheets parallel to the surface, which crumble under foot and make very unsafe walking, especially in descending a hill of this rock. In every case also, it forms the lower hills, never dominating those formed by the red variety, and so constant

are the characters above enumerated, that it is possible to determine this rock with certainty several kilometres off.

This rock, where it occurs in quantity and in a fresh condition, would make a beautiful statuary stone as it is remarkably free from blemishes.

**Coast range.** The southernmost point at which the true porphyritic granite occurs is in Gebel Ghub in the coast range extending from Ras Gehân on the north, to the mouth of Wadi el Araba, near which the above hill is situated. In this range, as previously stated in the description of the red granite, there is a complex of different rocks, the most important of which are the pink granite and granophyre or fine-grained granite; into the latter the former sends veins and apophyses, the whole being likewise cut by red granite and dolerite intrusions. The main mass of the range may be said to be composed of pink granite and granophyre, and the various peaks, viz., Gebel Batn, Abu Hoshwa, Abu Gatâr, with the exception of Abu Darba, are likewise composed of this rock.

**Wadi Meâr.** In Wadi Meâr near the mouth of Wadi Khrêta, pink porphyritic granite is seen intruded into the grey granite which here forms the country rock.

**Wadi Hebrân.** Further north in Wadi Hebrân this rock occupies a tract of country roughly 6·5 by 2·5 kilometres in size, stretching from Gebel Wagîra and Hebrân on the north, to Gebel Weber on the south, and from Wadi Emlaha on the west to the foot of Gebel Matak el Barûd, a range of gneiss and metamorphic rocks which has been metamorphosed by contact with the granite. In this area the typical rounded summits and dome-like hills are seen with no outstanding points to help one to distinguish one from another.

**Gebel Hebrân.** In Gebel Hebrân the pink granite is veined by the coarse red variety; while a dyke of quartz-felsite about 3 metres wide, running east and west, and extending from Gebel Wirga on the west, a distance of 5 kilometres, cuts this hill and continues for several kilometres further. Numerous veins and dykes of dolerite are also met with in this hill, and seem to radiate from Gebel Moreia or Tarbush.

**Gebel Wirga, Ramuz, and Geba.** Another patch of this rock forms the foothills to the range of Gebel Serbâl, occupying an area of 13 by 6 kilometres or so. This area extends from Wirga on the south to Wadi Geba on the north, and from Gebel Serbâl on the east to El Qâ on the west, including in it Gebel Sigillia, Wirga, Ramûz and Geba. Compound dykes of quartz-felsite and dolerite cut these hills in an east-and-west direction, while simple dykes of the former rock also occur like that mentioned previously as extending



GRANITE VEINING DIORITE, WADI MEAR.



from Wirga to Gebel Hebrân. The granite in this area is typical in its style of weathering, some splendid examples of domes being met with on the summit of Wirga and the Fersh el Ramûz.

Its relations to the neighbouring rocks are very distinct ; it is cut and veined by the coarse red granite, while in turn, it intrudes into the gray micaceous variety, which lies on it to the south.

This rock is not met with again until the middle of Wadi Solâf is reached ; after passing the gneiss and schist which form the sides near the mouth of this wadi and the metamorphic patch at Gebel Um Esnân it once more occupies the field. In this hill there is a complex of rocks formed by contact metamorphism, this granite being the agent which produced the metamorphosis, by sending apophyses into the shales and limestones which compose it. Veins also are met with in the gneiss and schist which also undoubtedly belong to the same rock. Beyond the area of metamorphic rocks which lies round the Naqb Engawe and the mouth of Wadi Solâf, the pink granite is seen to occupy the whole of the country from the foot of Gebel Moreia or Tarbush up to the Naqb Hawa, Gebel Gharbi and Watia on to and beyond Wadi el Sheikh, a distance of 23 kilometres, while the breadth is 10 kilometres. The eastern boundary has not been seen, but on the north it is seen to be bounded by a mixture of pink and gray granites at the head of Wadi Magheirat, the line being parallel with Wadi el Sheikh until within a kilometre of Wadi Solâf when it crosses the water parting between Wadi el Akhdar and El Sheikh and connects with the next area to be described to the north. About 2 kilometres west of Wadi Solâf it crosses Wadi el Sheikh and sweeps round toward Gebel Um Esnân.

Between these two wadis the pink granite forms the main rock, being cut by two sets of doleritic dykes one of which runs S.W.-N.E., while the other is at right angles to the first, being the older and more basic and weathering spheroidally, often forming a trench and attaining the width of 6 metres. They also form compound dykes with the red granite. This causes the pink granite to be thrown into ridges where the harder set of dykes predominates; while in the places where the two sets are in equal quantity it forms rounded hills. Behind Gebel Watia it also appears and is cut by dykes of granophyre, while further up Wadi el Sheikh it is replaced by red granite.

The next patch to be described is that which lies on either side of Wadi el Akhdar, and is connected to the last-mentioned piece by a narrow band. In length it is 12·5 kilometres by 7·5 at its greatest width. It begins about a kilometre to the south-west of the mouth of Wadi Barra. On the north of Wadi el Akhdar the boundary runs

Gebel Um  
Esnân.

Country  
between Wadi  
Solâf and Wadi  
el Sheikh.

up Wadi Retema until near its head, where the large boss of red granite crops out. Beyond this boss the boundary line to the north-east is practically on the line of Wadi Esh, from thence running in a north-easterly direction by the head of Wadi Bum to Naqb Shêqer, then bending south once more towards El Akhdar, which it touches about 2 kilometres from En el Akhdar, from which point it runs more or less parallel to this wadi, until it connects with the mass previously described. On the north-east it meets the gray granite, while on its southern side it has a mixture of the pink and grey varieties. Through it run dykes of quartz-felsite (S.W—N.E), and dolerite N. of E. and S. of W.

Between Wadi  
Shellâl and  
Sidri.

The next place where this rock occurs in mass is between Wadi Shellâl and Sidri, where it forms a high ridge of hills 10 kilometres long by 5 at its greatest extension. It bears a few isolated outliers of Carboniferous beds, and further to the north eventually disappears under this formation altogether. From this patch a narrow strip runs along the side of the fault line across Wadi Shellâl, where it forms a small boss bounding the valley. This is undoubtedly the same as that which forms the east side of Wadi Baba, the connection being hidden by a thin covering of Carboniferous beds. In this district it is intrusive in the gneiss, which forms a good part of the country round this place.

Opposite the mouth of Wadi Budra, on the side of Wadi Sidri, a small knob of this rock is exposed from under the Carboniferous sandstone, being evidently part of the main mass faulted down.

Gebel Ât el  
Gharbi.

(Ic) *Grey granite*.—Beginning at the most southerly occurrence of this rock, the first to be described is that of Gebel Ât el Gharbi, where there is a complex of andesitic dolerite, fine-grained granite, diorite, red granite and this rock. Round the base of this hill, the foot-hills are composed of grey granite.

Wadi Um  
Malaqa.

Going northwards the next patch met with is at Wadi Um Malaqa, where there is a mixture of a coarse, red granite and a porphyritic grey variety. From this point to Wadi Emlaha none of this rock is met with, but at the latter place grey granite passing into diorite, or quartz-diorite is met with. There, up to and beyond Wadi Shiddiq, it forms a triangular patch in the foot-hills, its apex pointing northwards. Its greatest length is 12.5 kilometres, and its breadth is 10 kilometres. Along the edge of the main hill-mass is a fringe of dioritic rock much cut up by a grey granite. On reaching Wadi Meâr it is found that grey granite has usurped the ground entirely, as it appears on both

sides; it extends southwards almost to the crest of Gebel Wigrân; eastwards as far as Wadi Khrêta; northwards about a third of the way between Wadis Meâr and Hebrân; until about one third of its length from its mouth it crosses over to Wadi Hebrân, running in a northerly direction until it meets the pink granite of Gebel Wirga. This mass is cut by a few veins and dykes mainly of dolerite; but in Wadi Ilti red granite cuts it; while there are also compound dykes of an augite-diorite and a micro-granite, and higher up quartz-felsite dykes become abundant some of them 6 to 9 metres wide.

Fluidal felsites are also found in this wadi; while in places also the granite becomes very micaceous.

In Wadi Hebrân near its mouth, grey granite cuts a dioritic rock and is itself veined by a white binary granite. In the granite in this wadi very micaceous patches occur, and dykes of dolerite (S.W.-N.E.) likewise cut it.

The next place where this rock is met with is in Wadi el Sheikh, <sup>Wadi El Sheikh.</sup> about half-way between Wadi Magheirat and its mouth. It extends to within one kilometre from the mouth of the wadi, then becomes gneissose, and in about 600 metres from this point passes into a true gneiss. This patch is somewhat irregular in outline, and sends a long, narrow tongue up the side of Wadi Solâf, between the gneiss and the pink granite. In its greatest length and breadth it is 15 by 7·5 kilometres. On the north it is bounded for a while by the drainage line of El Akhdar, the junction-line between this rock and the red granite having evidently determined the course of the wadi; but further up the water has evidently departed from this line, as the grey granite sends a tongue in between the red and pink varieties, the boundary lines in this case being likewise marked by the tributary wadis of Satakh and Retema. On the east and south it is bounded by a large area of the pink variety. In this area the rock is much dyked by dolerite and red felsites.

The next grey granite area occurs between Gebel Yenna and Banât on the south, over the wadis of Rumâna and Rahaba up to wadis Sidri and Siq, on the north, and east as far as that of Barq. It runs up wadi Siq for about 10 kilometres, and is seen wherever the small branch wadis have cut through the Carboniferous sandstone, so that it undoubtedly forms a continuous sheet underneath the latter rock. It is bounded on the south and west and north by the gneiss hills which lie on the north side of Wadi Ferân, and also form the hill-mass between this valley and that of Sidri and Um Agraf, and on the east by the complex of pink and grey granite and the red variety near the

head of Wadi Lebwa. The gneiss above-mentioned has undoubtedly been derived from the grey granite. The patch under consideration has a maximum length and breadth of 20 by 19.5 kilometres, being widest on its southern side. This rock forms a large, high plateau without any prominent points, except where there are intrusions of other rocks, e.g., the red granite patch overlooking Wadi Nisrin, and the syenite intrusion near Wadi Aqr. Its surface is divided into flat-topped patches or fershes, e.g. Fersh Nisrin, Fersh Sidri, and Fersh Abu Aleqa, each being named from the wadi which drains it. In its southern part it is very much dyked mainly by dolerite, as much as one fifth of the entire rock being composed of this rock. The latter weathers very easily and in a spheroidal manner, in most cases being rather lower than the surrounding rock. A prominent, red dyke of quartz-felsite, from 3 to 4 metres wide, makes its appearance near the intrusion of red granite overlooking the Nisrin valley, and is continued into the plateau where it could be traced a distance of 6.5 kilometres.

From the beginning of Wadi Siq to the mouth of Wadi Barq, there is a boss of quartz-felsite intruded into this rock which forms steep scarps on the sides of both these wadis.

Wadi Um  
Shêqer, etc.

The only other place where this rock occurs is in the neighbourhood of Wadi Um Shêqer, Entish, etc., where it is capped by isolated outliers of Carboniferous sandstone. On the west it adjoins an area of metamorphic rocks; on the north and east it disappears under the Carboniferous sandstone; while on the south it is cut off by the pink and red granites. This patch has a maximum length and breadth of 12.5 by 7.5 kilometres. It is much cut by dykes of fine granite and quartz-felsite.

With regard to the relations between the metamorphic complex and this rock, no definite evidence could be found, but the presumption is that the fundamental rock of the former is the older.

This grey granite, on account of this being fairly rich in mica, lends itself to easy weathering, and also tends to form flat-topped hills or plateaux, instead of rugged ridges. Its tendency to become gneissose is also fostered by its wealth of mica, and there is little doubt that all the gneiss on the western side of the peninsula at least has been formed from this rock.

*Mixture of pink and grey granite.*—Under this title has been mapped certain areas composed of such an equal mixture of these two kinds of granite that it was impossible to separate them except by spending months surveying them on a large scale, a work which would not

justify the extra expenditure. These areas form a crescent-shaped mass, the points of which lie at the head of Wadi Sheqer and the mouth of Wadi Harqûs respectively, while the middle is at En el Akhdar. The grey granite is gneissose, as is sometimes also the pink variety, while the mass is much cut by dykes of quartz-felsite and dolerite. Its southern boundary does not reach Wadi el Sheikh, while its eastern boundary was not reached as the party had to turn westward in order to finish the remainder of the country.

2. *Syenites and diorites*.—Of the former there are only two known occurrences, viz., a small boss 1·5 by one kilometre in the grey granite plateau on the north of Wadi Aqr, and in the mass which forms the north side of the plateau of Gebel Yenna and Banât. The latter is intruded into red granite, and on the south side is another small tongue of the same rock, between the two being numerous small dykes, which are good examples of fluidal intrusions. The rock is dark-red with porphyritic feldspars in a felsitic ground-mass. The patch is roughly triangular in outline, and measures 10 by 7·5 kilometres at its widest part. It seems a fairly hard, resistant rock, and the formation of the plateau is no doubt due to its combination with the red granite, the softer grey granite and micaceous gneiss having weathered more easily leaving the harder rocks standing high above their neighbours.

Diorites are first met with in Wadi Emlaha which drains the Um Shomer range on the west. Here it passes insensibly into quartz-diorite. At the mouth of Wadi Meâr it occurs on either side, and is a very fine rock rich in hornblende, and much cut by a grey biotite-granite. Further up it occurs in a patch near the foot of Gebel Madsûs, but here it is a more micaceous variety. It is much cut by wide dykes and veins of quartz-felsite.

3. *Dykes and veins*.—Although the igneous area is more or less dyked and veined all over, still in certain places they are more crowded together than in others, while the rocks call for special mention on account of some characteristic which they possess. Starting from the south, the first to be noted are the dykes in the outlying hills to the west of Gebel Tihi. These are much cut by doleritic dykes running N.E.-S.W., while there is also a porphyritic quartz-felsite dyke about 3 metres wide, which shews fine secondary growth of the feldspars. Further north, to the west of Wadi Temân, the outlying hills are also much cut by dolerite and quartz-felsite, while the main range is also streaked by these, the dolerite being the younger. In the foothills of Um Shomer there are east and west dykes of quartz-felsite.

Wadi Altî.

In Wadi Iti augite-dolerite forms compound dykes with a micro-granite having a bearing S.W.-N.E; quartz-felsites are also very abundant higher up, ranging from 6 to 9 metres in width; while others are narrower and more glassy, exhibiting good fluidal and spherulitic structures. In addition to these some dolerite and diorite dykes were also seen. Gebel Sawasia at the head of this wadi is much cut up by fine grained quartz-felsite while Gebel Giddet el Ela, Wigrân, etc., are literally cut to ribbons by dykes, the former deriving its name from this (see Topography p. 81). In Gebel Ramûz and Geba compound dykes of quartz-felsite and dolerite are found running in an east and west direction.

Gebel Sawasia.

Wadi Hebrân.

The coast-range is much dyked and veined by a fine-grained dolerite. In Gebel Hebrân, a quartz-felsite dyke 3 metres wide and running S.E.-N.W., is seen to be continuous from Gebel Wirga, a distance of 7.5 kilometres. A few dolerite dykes also occur which seem to radiate from Gebel Mareia. At the head of this wadi, quartz-felsite and a syenite-felsite cut the gneiss in that region.

Country  
between Wadi  
Gharbi and El  
Sheikh.

In the area between Wadis Gharbi and El Sheikh two sets of dolerite dykes are met with, one running S.W.-N.E., the other and older runs at right angles to the first, and reaches a width of 6.5 metres, weathering spheroidally, and forming trenches in the granite, while the former stands slightly out. The younger dykes have been traced into the doleritic neck of Gebel Mareia, and are seen to radiate from this mass or its probable extension underground. The older set forms a compound dyke with the red granite. Round about Wadi el Sheikh outside El Watia, dolerite dykes, ultrabasic rocks in sheets and veins, and a syenite-felsite dyke running N.W.-S.E. cut the granite. On either side of this wadi the two sets of dolerite dykes persist, the orientation of the younger changing until it becomes almost north and south. When examined in the field this rock splits into thin splinters under the hammer, and seems to contain feldspars resembling orthoclase, but this must be settled by the examination of thin slices under the microscope.

Wadi Ferân.

Near the head of Wadi Ferân the dykes in the gneiss are mainly quartz-felsite, although a few are doleritic too. Numerous veins of pegmatite also occur in the gneiss. Below the mouth of Wadi el Akhdar the gneiss is simply riddled with dykes and veins, the former being mainly quartz-felsite, some of which attain a width of 6.5 metres. These belong to two periods, the elder running S.W.-N.E., while the others bears N. and S. Interlacing these are numerous veins of dolerite mainly lying in a N. and S. direction. This mixture of rocks pro-

duces a multi-coloured mass, which when seen with the setting sun on it is simply wonderful, the bright red of the felsite, the dark-brown of the dolerite, and the sombre hues of the gneiss combining to produce a very striking effect. This state of things persists for about half a kilometre and then returns to the normal state. Below the Oasis of Ferân, dykes of several kinds occur in the gneiss, of which two are quartz-felsite (one of them gneissose), while fine-grained red granite and the pink, porphyritic variety occur as veins and intrusions. Further down there is a great increase of dykes once more, these being mainly of the doleritic type much weathered and lying in a north and south direction.

Returning up Wadi Rummâna, in the plateau overlooking Wadi <sup>Wadi Rummâna and Rahaba.</sup> Nizrin, a remarkable dyke 4 metres wide is met with in the red granite. It is doleritic and contains some very large feldspars measuring 7·5 by 2·5 centim., some of which also form glomeroporphyritic patches. In Wadi Rahaba (the continuation of Wadi Rummâna) there occur dykes and veins of dolerite and quartz-felsite, while in the latter wadi the doleritic intrusions are so numerous as to form about 1/5 of the entire rock.

In Wadi Aqr, in the metamorphic complex in which it heads, there <sup>Wadi Aqr.</sup> are numerous thin dykes of quartz-felsite, but the diabases form wide intrusions.

Near the mouth of this wadi, the high plateau of Gebel Yenna <sup>Wadi el Akhdar.</sup> contains some fine examples of veins of fluidal rocks. Higher up the valley to the east of Wadi Bârra, the granite is much cut by S.W.—N.E. dykes of dolerite, some of them 6 metres wide. Further on beyond the mouth of Harqus, a dyke of porphyritic quartz-felsite S.W.—N.E., and one of dolerite N. of E. and S. of W. were met with; while at En el Akhdar a boss-like mass of coarse, porphyritic quartz-felsite is seen, as well as several other smaller dykes of this and a doleritic rock.

In Wadi Sheqer there are many dykes of fine granite and quartz-felsite in the metamorphic area. In the neighbouring Wadi Barq occur veins and dykes of a felsitic rock, together with S.W.—N.E. dykes of dolerite much decomposed. These occur in the metamorphic complex previously mentioned.

Near the junction of the above-mentioned wadi with that of Siq, there occurs a boss of quartz-felsite in the gneiss; while further up the latter valley a dyke of gneissose quartz-felsite is met with; and in the continuation of this waterway (Wadi Um Agraf and Sidri), dolerite and felsite dykes, having a north and south bearing, abound.

Dykes in  
sedimentary  
rocks.

Leaving the igneous and metamorphic areas, the dykes and veins in the sedimentary district only remain to be noticed, the first being those of Gebel Hadud. This hill is an isolated knoll of Cretaceous limestone lying on the north-east corner of the plain of El Markhâ. In it occur some black veins of a tachylitic basalt about 30 centimetres thick.

Not far away from this hill, a dyke of dolerite, running north and south, is seen to cut the Carboniferous limestone in Wadi Shellâl, but as it was not met with on the surface of the plateau, it may be concluded that it is not one of the later dykes.

On the edge of Wadi Baba, near its junction with that of Suwîq, a much-decomposed dolerite dyke cuts the Carboniferous sandstone, but is soon masked by blown sand, its bearing being south-east-north-west. This is the intrusion from which M. Raboisson\* formed his opinion that the igneous rocks were later than the sandstone and had been intruded into them.

Wadi Nokhel.

In this wadi where it enters the sea, a dyke of dolerite 5 to 6 metres wide cuts through the limestone and enters the sea a little to the south. Its bearing is practically north and south, and it was again met with in Wadi Hamr apparently continuing for some distance to the north. Where it joins the limestone its edges are tachylitic, and hydrocarbons have been developed in the rock which gives off a strong smell when struck by the hammer. This is true of every place where the junctions have been examined. In two other places in Wadi Hamr small veins were seen in cracks.

Gebel  
Hammâm  
Farûn.

The next place where a dyke was seen was in Gebel Hammâm Farûn, where a N.E.—S.W. doleritic intrusion pierced it on the southern side. It was not noticed on the north side, however, and may be only local, as in the next case which occurs on the divide between Wadi Abu Qâda and Bagha. Here, what appeared at first to be black limestone was found, but on examination proved to be a dolerite dyke with a fringe of dark limestone on either side. This intrusion was not seen to extend any distance. The reason for this perhaps is that as the dyke occurs in the Cretaceous marls, and they are exposed only for a short distance, it may not have penetrated the higher beds. In fact, it did not seem to reach the upper beds of these marls.

4. *Lava flows*.—These are found in two districts only, viz., that extending from Maghara up Wadi Baba and on to the Debbet el Ramli, and in Wadi Tayiba. Taking the first one, the first patch of volcanic

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\* Op. cit.

rocks found was on the hill-top overlooking the turquoise mines in Gebel Maghara. Here it was a coarse basalt about 27 metres thick, and evidently a subaqueous flow, as no signs of steam-holes or scoriæ were met with to suggest a subaerial origin. This patch must have been continuous with the other three which are seen in the neighbourhood, part of it having been carried down by a trough-fault which lets the Cretaceous sandstone into the plateau. This first patch is about 2 by 5 kilometres in length and breadth. To the north of Wadi Qena the largest patch of this rock is found; on the east it is bounded by the main line of fault, which has let down the whole of the country to the west. In character it is like the others, and in shape, a long, narrow triangle measuring 5 by one kilometres. Close to it is another small patch separated only by a small drainage way. The next large patch occurs just behind the high granite ridge which overlooks Wadi Shellâl. It is an irregular piece which has been let down by a V-shaped fault into the sandstone.

On the top of Serabît el Khâdim and the hill immediately to the north-east of it are found caps of this rock. It is to this that the peculiarly rounded appearance of these hills is due. The last occurrence of this rock is met with on the top of Gebel Hameier on the edge of the plain of Debbet el Ramli. It forms a steep scarp to the south, gradually thinning out and disappearing under the blown sand of the above-mentioned plain. The thinning is due entirely, as far as could be seen, to the erosive power of the sand-blast which is here very powerful. Its thickness here is about 39 metres, and its total area is 5 by 2.5 kilometres. Underneath these patches a certain amount of alteration of the underlying rock has taken place, the sandstones being converted into quartzites. Other hills have been met with having this alteration-layer, and this has been regarded as a proof of the former greater extension of the basalt.

*Age of this lava.*—It is difficult to assign a definite age to this rock, as there are not sufficient data from which to arrive at a certain conclusion. After some search among the underlying sandstones two specimens of *Lepidodendron* were found, this shewing that they were in all probability of Carboniferous age, but no result was obtained from the beds, which are higher than the basalt. It has therefore been regarded as late Carboniferous in age. This rock is so constant in its position, that it has been used successfully as an indicator of the upper boundary of the Carboniferous sandstone, the lines closing up perfectly although it was used over a fairly large area. That it is not

an intrusive sheet is fairly certain, as in the many exposures it is to be expected that some definite evidence of its eruptive nature would have been found. Moreover, an intrusive sheet, as a rule, has a definite outcrop along a certain line, and does not occur in isolated patches, forming a sort of crescent with its concavity to the south-east. The source from which these rocks have been derived is a more doubtful matter. The next class of rocks to be described, viz., volcanic necks, shews such a suggestive relationship to these flows when the two are plotted on a sheet, that the conviction is borne in upon one that these necks are the remains of the vents from which these basalts have been poured.

Wadi Tayiba.

The next place where lavas are met with is in Wadi Tayiba, especially on the south side of it. The first patch occurs at the mouth as an interbedded lava in what has been described as a Beach Deposit (Miocene). It is a much decomposed basic rock, is tilted at a steep angle, and is only about 12 metres thick. It has probably been torn away from the other interbedded lava by a fault which has thrown the latter down against the Cretaceous rocks. As to the source of these rocks, it is impossible to say whence they came, unless the dyke previously described from this area is the remains of a fissure from which they were poured. The fact that they thin out towards the east is against this, so that the most probable place to look for their source is under the waters of the Gulf of Suez.

5. *Volcanic necks.*—These rocks, as already stated above, form a sort of horse-shoe with the convex side turned to the north-west. They occur in the hills of Gebel Koli, Abu Mezraq, Sawasia, Madsûs, Mareia and Samr el Tinia.

The ridge of Koli and Abu Mezraq is a large mass, over 7 by 3 kilometres in length and breadth, rising with sheer sides through the granite which forms the country. Apparently connected with it by a narrow injected fissure is Gebel Sawasia, another mass 2·5 by one kilometre, which rises up the centre of the hill, exhibiting all the characters of a volcanic neck, and on one side forming a sheer cliff where the granite has been removed. Four or five kilometres to the north of the last occurs the hill of Madsûs, the centre of which is formed of a mass of coarse dolerite similar to that which forms the other masses previously mentioned. Further to the north-east occurs the hill of Gebel Mareia, which is composed of a mass of dolerite over 5 by 3 kilometres in length and breadth, while eastward is the mass of Samr el Tinia, which is made up of the same rock. All these masses are coarse

dolerite which veins the granite in which it occurs and often sends dykes out into the surrounding country. If, as has been stated in the part on the lavas, these are the remains of the vents out of which the lavas were poured then their age is late Carboniferous, and the dolerite dykes which occur in the gneiss and other rocks on which the Carboniferous rocks are laid, are older and belong to another period to that of these necks. It has been stated previously that there were two sets of dolerite dykes one of which was connected with the large masses of dolerite and was the younger; it is therefore likely that the older series is not in any way connected with these necks.

## (II) METAMORPHIC ROCKS.

1. *Gneisses and schists*.—These rocks occur in the district lying between lat.  $28^{\circ}36'$  and  $29^{\circ}$  N, and long.  $33^{\circ}30'$  and  $33^{\circ}50'$  E. They can be roughly divided into two groups, viz., true gneisses and schists, and a complex of metamorphic rocks. Taking the last named group first, it occurs in one large patch extending from the neighbourhood of Wadi Barq eastward as far as the Wadi Siq. This is composed of two fundamental rocks associated with several others of minor importance, these being:—

1. Much altered micaceous rock.
2. Altered felsite rock, which becomes, at times, schistose and is then the same as that known as "quartz-schiefer" by the German petrologists. This seems to form the fundamental rock in places, while in others it is intrusive in the micaceous rock, thus proving the latter to be the older.
3. Capping the hills is a gneissose basic rock and hornblende-schist.

In this complex occur the following intrusions:—

1. Veins and dykes of a felsite rock.
2. Reddish granite rock.
3. Granite with large feldspars ( $5 \times 2.5$  cent.).
4. Dykes of a much decomposed doleritic rock running S.W.-N.E., and younger than all the others.

This complex has been entirely covered at one time by the sandstones of Carboniferous age, and as a consequence presents a flat surface with no crests standing out to relieve the monotony. It has evidently been produced by the erosion which took place as it subsided under the water prior to the deposition of the sandstones.

The group of true gneisses and schists occupies a much larger area.

On its southern side it abuts against Gebel Madstûs and Mareia, continuing from there along either side of Wadi Ferân; its western edge flanks the range of Serbâl; while its eastern boundary skirts the base of Gebel Goze and Banât, and passing on into Wadi Rahaba and Rummâna keeps all the while more or less parallel to Ferân. This rock extends down Ferân as far as the sedimentary area, where it is cut off by the great fault which follows the line of the hills. From this point it runs parallel with the fault until near Wadi Sidri, where it gives place to the pink granite, passes round to the east, and occupying the country on either side of Wadi Um Agraf (the continuation of Sidri), eventually disappears underneath the sandstones, but always shews wherever a wadi has cut through the latter. It is last seen round the mouth of Wadi Baba, but it undoubtedly persists under the Carboniferous rocks for a good distance. As has been stated in the account of the dyke-rocks, this rock is very much cut up by dykes in Wadi Ferân. In its characters this rock is very constant all over the area. At the head of Wadi Hebrân, where it was first encountered, it consisted of a fine biotite-gneiss interlaminated with mica-schist, and well-banded quartzose veins also running through it. In places there is a tendency to pass into mica-schist by the increase of mica. The inclination of the shear-plane is towards the south. Associated with this gneiss in Gebel Matak el Barûd is a garnetiferous rock of siliceous appearance; but a crystalline limestone is also mixed up with it. There must have been some powerful force acting here, for some excellent examples of crumpling are seen, the axes of the folds being in a vertical plane. In one place a fold was seen in the form of a horse shoe only 2 metres across, and with much sharper folds inside it. In Wadi Ferân the gneiss is more normal, and the bands of mica-schist are not much in evidence. Below the Oasis of Ferân, in one of the small wadis which come from the sedimentary area, some fine examples of crumpling were seen, the black micaceous bands standing out from those of white felspar. In the lower half of the Wadi Um Agraf the gneiss returns to the Hebrân type—a mixture of fine-grained biotite-gneiss and schist. Further up the wadi the coarser variety comes in, and continues until the sandstone country is reached. In Wadi Baba and its tributaries, the gneiss is a dark-grey fine-grained rock, approaching a schist in character.

*Origin of the Gneiss.*—On this side of the peninsula there does not seem to be any doubt as to the origin of this rock. It was pointed out in the description of the grey granite that, at the mouth of Wadi

el Sheikh, this rock first of all became gneissose, and very shortly afterwards passed into a true gneiss. This has been seen at various places, the two rocks shading into each other. It thus seems indubitable that this rock is simply the result of the deformation of the grey granite. The cause of this is probably to be found in the eruption and intrusion of the granite mass of Serbâl. A glance at the map shows the gneiss to form a sort of fringe round the base of this mass, gradually shading off on either side into the normal grey granite.

The age of the gneiss can only be fixed within wide limits. It is known to be prior to the deposition of the Carboniferous sandstone, and subsequent to the intrusion of the pink porphyritic granite, which is also earlier than the sandstone, but is evidently subsequent to some limestones, shales, and sandstones to be described immediately, which it has metamorphosed so completely that all trace of fossils has been obliterated. As these rocks are involved in the same folds as the gneiss it follows that the gneiss belongs to the same period. All that can be said, therefore, is that the gneiss was formed in post-Archæan times and probably in the early Palæozoic period.

2. *Metamorphic limestones and schists.*—These occur mainly in one patch in Gebel Um Esnân, although they were also seen in Gebel Matakh el Barûd, associated with the gneiss above-mentioned. In the former hill it would seem that these rocks have been faulted down against the gneiss as the remains of its bedding is not very far from the horizontal. The beds seen here are crystalline limestones, altered shales and sandstone, the metamorphosing agent being the pink granite which forms the country round about. In the two former rocks, garnet is very abundant, occurring in large irregular masses, rather than in good crystals, and becoming a veritable “granat schiefer,” while the sandstone shows biotite and perhaps felspar. The complete description of these rocks must wait until the thin sections, which are being prepared, have been examined. As to their age enough has been said in the previous paragraph to indicate the extent of the writer’s knowledge concerning it.

It is now possible to give a tabular statement of these rocks in the order of their age, beginning with the oldest:—

1. Diorite.
2. The grey biotite-granite.
3. Biotite-gneiss and schists, together with the Metamorphic limestone and sandstone.
4. Pink porphyritic granite.

5. Coarse Red Granite.
6. Syenite and Syenite-felsite.
7. Quartz-felsite and dolerite dykes (older series N.W.-S.E.) ; relations between those two uncertain, but reasoning from analogy the basic is the younger.
8. Dolerite dykes N.W.-S.E., dolerite-necks and the lavas of the Carboniferous period.
9. Dolerite dykes in the Cretaceous rocks.
10. Lavas younger than the Cretaceous in Wadi Tayiba.

The following is probably somewhat like the sequence of events in this district. During Archæan times the grey granite and diorite were intruded into old Archæan rocks, which were subsequently removed by denudation to form the later sandstone. Later on, sandstones and limestones were deposited on the exposed surface of the granite, to what extent is not known. Following this came a disturbance which developed into a thrust in a north-easterly direction, in all probability being caused by the intrusion of the pink porphyritic granite along the line of the present Serbâl range, shearing the grey granite and setting up gneissose structure. This movement continued until Serbâl and other ranges, had reached their full height, the coarse red granite having pushed all the others up into a big dome, which was subsequently denuded leaving them as they now stand. In the wake of this came other movements, causing numerous fractures S.E.-N.W., and N.E.-S.W., which were injected by quartz-felsite and dolerite dykes, many of these having been opened previously as they contain compound dykes of granite and one of these other rocks. After a time, during which denudation was very active, and the district was slowly sinking under the sea, the deposition of the Carboniferous took place, towards the close of which period the volcanic vents above described were opened, and the lavas above-mentioned were poured out, certain new fissures being formed and injected with dolerite. After this a period of quiescence and steady deposition took place until Eocene times, when a few cracks in the secondary rocks were injected. The last occurrence is the outpouring of the lava in Wadi Tayiba. This took place, as has already been stated, in Oligocene times, the lava occupying the same position as it does in the district between Cairo and Suez.

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## SECTION IX.—ECONOMIC GEOLOGY.

Of the various products of this area, perhaps the most important is the <sup>Granite.</sup> large area of grey granite, which is suitable for statuary purposes. This is best developed in Wadis Meâr and Hebrân, although it also occurs to the south in Wadis Shiddiq and Emlaha. From the former of these localities there is no difficulty about transport, as waggons could be run on a light railway attached to a rope, the laden ones running down to the sea coast by gravity, and drawing up the empties at the same time. At El Tor the stone could be put on board boats and conveyed to Suez or Port Said, if required, the expense being in this way reduced to a minimum. A good supply of water would be easily obtained in the wadis, as the rainfall is quite sufficient to produce a constant supply if it were collected. In fact, in the winter season, running water is met with in many of the wadis.

The next thing of importance is a pure white sandstone, very friable, <sup>Sand.</sup> and which, on account of its freedom from iron-oxide, would be very useful in glass-making. This sandstone occurs at the foot and in the cliff of Gebel Dhalâl, where there is about 200 metres of good stone. The only draw-back to its use is the distance of transport, although a fairly good road could be made with little difficulty to the sea.

Perhaps as valuable as the foregoing are the iron and manganese <sup>Iron and manganese ores.</sup> ores of this district. These occur in the Carboniferous formation at the base of the limestone at its junction with the sandstone. They evidently occur more or less in "pockets," but as far as was seen they exist everywhere where the limestone is exposed, and vary in thickness from 0·6 to 1·3 metres. In different places the ore varies in composition, sometimes being pure hæmatite, sometimes an admixture of that and the oxides of manganese, while in others it is pure manganese oxides. The three places where it was examined were Wadi Malha, Wadi Nashb, and at an old mine in Wadi Halliq. In the former locality the two ores lie side by side, as if they had segregated so, being more or less distinct from each other, but on their junction being intimately mixed. The same is true of the second locality, but in addition there is a fair quantity of earthy manganese-ore (wad). In the third locality the hæmatite is more abundant, the limestone being impregnated with it near its base, while nodules of pure ore weighing from 25 to 50 kilos. are frequent.

The following analyses made by A. Lucas, Chemist to the Survey Department, give the general composition of these ores :

WADI MALHA.

Number	Fe <sub>2</sub> O <sub>3</sub> %	Fe %	MnO %	MnO <sub>2</sub> %	Mn %
3946	46.96	32.87	..	..	..
3911	3.74	2.62	15.21	71.59	57.00

WADI HALLIQ

3970	25.34	17.74	..	38.19	24.12
3970 A	..	..	41.03	45.50	60.48
3970 B	20.14	14.31	..	39.95	25.23
3970 C	..	..	..	71.41	45.10
3971	27.60	19.32	14.60	40.81	37.03
3971 A	32.10	22.47	..	..	..
4135	2.32	1.62	..	30.33	19.16
4136	34.24	23.97	..	29.52	18.66
5000	69.34	48.54	..	3.06	1.94
5001	16.90	11.83	32.87	18.56	37.18
5002	98.24	68.77	..	..	..
5003	93.69	65.58	..	..	..
5004	73.62	51.53	..	9.58	6.05
5005	38.80	27.16	14.72	24.10	26.64
5006	25.86	18.10	..	..	..

In all these specimens the gangue was practically all silica ; traces of lime were found in all of them, while two of them contained as much as 16% and 18% ; nearly all of them were hydrated, although in some only a trace of water was found. This water may be either from the manganese compounds, many of which contain water, or from the brown ferric oxide which is nearly always associated with the hæmatite, the latter gradually passing into the former by hydration.

The percentages of iron and manganese given in the above table show at a glance whether the ore is a rich one and worth exploiting. The whole of the samples taken from Wadi Halliq were collected from an old mine which had been opened there presumably for the working of copper ores, most of the specimens being obtained from the rubble heap at its mouth. Specimen No. 3,971 A is a red ochre or raddle ; while Nos. 3,971 and 3,970 are black, earthy, amorphous substances like wad. An almost pure hæmatite is No. 5,002, while No. 5,003 follows closely on it. Of the manganese ores No. 3,970 A is a good example, being a very fair specimen of psilomelane, while 3,911 and 3,970 C also compare very favourably. The others are only varying mixtures of hæmatite and the manganese oxides, which owe their richness or

poorness to the quantity of gangue, and impurities with which they may be mixed. These may be useful in the production of manganese-steel.

The position of these ores is perhaps against their being profitably worked, situated as they are some little distance from the sea-coast where no fuel is obtainable. The other alternative of bringing the ore to the sea-coast and treating it there, or shipping it elsewhere, is therefore the least expensive, although the cost of transport might even then be prohibitive. The actual mining of the ore would not present much difficulty as the underlying rock is not hard and difficult to pierce.

Since writing the above, a copy of a paper on "The Manganese Deposits of Bahia and Minas, Brazil," by professor J.C. Branner \* has been received.

The difficulties of working the last-named deposits are very similar to those in Sinai. No fuel is available, and the whole ore has to be dug out and transported by rail to Rio, whence it is shipped in great part to the United States. The manganese deposits of Minas lie near the railway about 500 kilometres north of Rio, the cost of transport for all that distance has therefore to be borne by the mining company. This it seems able to do. After reading this paper, it seems as though the deposits in Sinai might also be worked at a profit. Appended is a table showing the percentage of metallic manganese in the different samples from various mines in Minas, with a column of the composition of the Sinai ores for comparison.

	Minas Mn %	Sinai Mn %
Sample from kilom. 499 Central Brazil Railway {	54.96	57.00
		60.48
" " " 500 " " " {	50.46	45.10
" " " 503 " " " {	50.44	37.03
" " Itabira kil. 524 " " " {	31.75	37.18
" " Vigia " 500 " " " {	55.40	26.64
	29.8	
" " Quelez Lafayette Station kil. 463... {	36.7	25.23
	60.1	
" " Rodrigo Silva kil. 521..... {	62.0	24.12
	60.9	
" " " " " " " {	49.7	
	51.4	
" " Hargreaves kil. 515 ..... {	48.96	
	57.40	

\* American Instit. of Mining Engineers, Sept., 1899.

There were other samples from Minas containing from 40% to 60% Mn.

A glance at the columns of the latter table shows that, taken as a whole, the Sinai ores are of a poorer quality, but taking into consideration their much closer proximity to the sea, there seems no reason to doubt that they might be worked at a profit, provided that the deposits turned out as rich as they appear to be by the analysis of the samples.

Copper.

Of the ores of this mineral, only traces have been found along the joints of the limestone. In the majority of instances these have been removed by the old miners who used Wadi Nasb as a centre of this industry. The surface of the limestone plateau has been searched diligently by them, and even the poorest veins have been worked out. The ore was mainly the blue and green carbonate, portions of which were found at various old workings.

Holland † suggests that probably all the material for the manufacture of glazes was obtained from Sinai.

Slag.

The only other ore found in this district was obtained from a heap of slag on Gebel Safariat, where it had evidently been smelted for copper, judging by the meagre traces of that mineral seen in it. A piece of it on analysis gave 23.46% of ferric oxide, while there was also a small amount of manganese likewise present. In the pounded up mineral were found several small pieces of metallic copper.

Bone-bed.

In this hill there occurs the only bone-bed known in Sinai about 0.3 metres thick. In character it is very similar to that found on the west side of the Gulf of Suez, and contains numerous teeth. An analysis yielded the following result:

Phosphoric acid ( $P_2O_5$ ) 24.63% = tricalcic phosphate ( $Ca_3P_2O_8$ ) 53.77%.

This analysis shows this deposit to be better than those occurring on the west side of the Gulf of Suez, the highest percentage of tricalcic phosphate being 50.78.

*Coprolites*.—In Gebel Hoshera a few nodules of a phosphatic nature, resembling coprolites, are scattered about in the yellow sandy beds which occur near its base. They are, however, not in sufficient quantity to make them of economic importance. An analysis of a sample yielded 12.94% tricalcic phosphate.

*Hydrocarbons*.—These occur all through the Cretaceous limestone,

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\* Op. cit.

† Op. cit.

their presence being discovered by the different dykes and veins which cut this rock, but they are in such very small quantities that nothing can be done with them. The only place where they seemed to be in quantity was at the mouth of Wadi el Araba where the white sandstone of the Nubian series is rendered absolutely black by impregnation with them. Even here, however, they were not in any quantity, the total loss on ignition being only 8·69%.

*Celestine*.—In the Beach Deposits of Wadi Amara on the Suez Road, there occurs veins of a heavy, brittle, crystalline, colourless mineral, which evidently belonged to the isomorphic group of rhombic sulphates. On being analysed it proved to be an almost pure sample of celestine (strontium sulphate) containing only 3·88% of impurities which are made up as follows:—

Water, carbon dioxide, and organic matter	... ..	2.00
Silica	... ..	0.69
Iron and Aluminium oxides	... ..	0.92
Lime	... ..	trace
		<u>3.88</u>

*Turquoises*.—These stones are known to occur at two places, viz., Gebel Maghara and Serabit el Khâdim, but in the latter place the quality is so poor that the work has been abandoned, although the former place is still exploited. The mines in Gebel Maghara have been worked by the ancient Egyptians since the beginning of the 4th Dynasty up to the time of Rameses II; while those of Serabit el Khadim were exploited up to the time of the 20th Dynasty. \* Nothing is known further as to their history until a Major Macdonald in the middle of last century settled at Maghara and took up the working of the mines, but he subsequently abandoned them as they did not pay expenses.

When visited in the early part of 1899, these mines were being worked by the Bedawin, nearly every man in the district having spent a certain time there at one period or other of his life. From information supplied by the Bedawin, it seemed to be the custom for the young men about to marry, to go to the mines and try their fortune, and if they were successful it enabled them to pay the necessary dowry for their wives.

In Gebel Maghara these mines extend over an area measuring 1·6 by 0·9 kilometres. This district is one in which considerable movement has taken place, faulting and folding being seen on all sides, and it is

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\* "Bedecker's Lower Egypt," 1885, pp. 491-93 and 523.

to this that the present restricted working area is perhaps due. To the north of the area the turquoise-bearing bed is thrown down beneath the surface by an east-and-west fault, while to the west the beds dip suddenly at a high angle, and run to earth in a very short distance, in this way confining the working area within very narrow limits.

The turquoises occur in a purplish-grey bed of sandstone which is of Carboniferous age. The master-joints of the rock run north and south, and east and west ; but minor cracks cross the rock in every direction and owe their origin to the earth movements. Threading the bed in question are numerous streaks of an ochreous, friable sand, which also forms "pockets" in the solid rock, and it is in this sand that the gems are looked for, and from it those of the best quality are obtained. Thin veins of turquoise of very inferior quality also line the sides of the joints. From men who have worked in the mines, it was learned that the stones lie very unequally ; men may go on working for days without finding anything, when shortly after a "pocket" is struck in which some very good stones are found.

The main workings occur in Wadi Qenaia, but a few also occur in Wadis Qena and Sidri. The best gems are, however, obtained from the mines in the first-named valley. The different mines are known to the Bedawin by distinctive names. The following are the names of the present workings :—

1. Hagaga.
2. Yahudia.
3. El Shebb.
4. Hadèd.
5. Um Hassan.
6. Sufra.

Under the first name are four mines which are worked, the most southerly having been only recently started ; the two middle ones are the oldest of the series, having a small gallery driven into the rock at the end of which is a vertical shaft, down which a guide went with a candle, and reported that no galleries went off from it. This may not be true, however, as the people block up the entrances so cunningly that it is difficult to detect them. In the fourth there was a shaft similar to the other two. The second on the list is said to be the most valuable, yielding stones of the best colour. It had a wide and high entrance-chamber, from which two galleries branched off into the hill. El Shebb has only been recently started as the face of the cliff is only being worked. The other three are being worked still, but they yield stones of inferior quality. From all sides there seems to a consensus

of opinion among the Bedawin that the richest mines are those in the neighbourhood of Yahudia.

According to Bauerman \* the turquoises occur about 250 feet above the bed of the wadi, in two beds about 15 to 20 feet apart. The most of the stones, however, are in the upper bed. The stones lie along the joint-planes lining the faces, and also occur in the centre of small red marly or ochreous nodules near the joints. In the latter places the stones of the better colour are found, those lining the joints being of poor quality. The miners evidently followed the joints, working out the rock on either side. This was then broken small and passed through a half-inch sieve, the coarser parts being brought to the mouth of the cave, and examined in daylight. The likely-looking pieces were then rubbed on a piece of coarse grit in order to see whether they contained turquoises or not; if any colour is apparent the stone is thought to be worth keeping.

Speaking of the mining tools used, this author says that flint chisels and stone hammers were used. In searching one of the smaller caves, several chips of stone hammers were found, as well as pieces of wood, some partially carbonised. These he considered to be parts of cylindrical blocks which served as mountings for the flint chisels used by the ancient miners.

*Origin of the turquoise.*—It has been stated by Holland that the turquoise occurs in cracks in a porphyry and in the sandstone, but this has not been confirmed by the present observations; no turquoises are seen near the basalt which caps the hill, the stones being found about 60 metres lower down. From what was seen and learnt from the guides it seems that the turquoises have been formed by percolating water and in no way owe their origin to igneous action. This agrees with the experimental results obtained in the artificial production of these gems. It is found that, if freshly precipitated phosphate of alumina be coloured by a solution of blue chloride of copper, dried at a gentle heat, and then subjected to enormous pressure, a gem is obtained which is little inferior both in colour and polish to the natural stone. In this district the conditions necessary for the production of these stones have been present at some former time, as is evidenced by the presence of the previously-mentioned folds and faults.

It is difficult to form any opinion as to whether these mines would yield a sufficient return for the labour spent in working them, as the

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\* Op. cit.

people are very averse to giving any information about the quantity and quality of the stones they obtain. It seems certain that the Bedawin make sufficient out of them to allow of them buying gunpowder and using it freely, while the people in the vicinity seem to be fairly prosperous, and able to buy grain in large quantities, and store it for use in the summer. This is unusual among Bedawin who are, in general, extremely poor. There seems to be a regular trade in turquoises carried on between merchants at Ayun Musa and the Bedawin, who barter the stones for gunpowder and other stores.

The way in which the mines are worked is very slovenly, all the rubble being thrown back behind the workers thus blocking up the exit more or less. If the people can make it pay working in this careless manner it seems that it ought to be made a fairly profitable concern with improved methods of working and economy of labour. To develop these mines it would be necessary to spend some money in making proper galleries from which to work the turquoise to advantage, and for this a certain amount of capital will be required.

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#### SECTION X.—DENUDATION AND WEATHERING.

This subject has been treated at some length in a previous report (\*) in which the agents at work in a comparatively rainless country have been set forth and discussed. These agents are equally potent in the district under description, but there are others peculiar to it, which are of comparatively little importance in a country in which desert conditions prevail. These are as follows:—

1. Rainstorms.
2. Frost and snow.
3. Action of moisture, containing carbon dioxide.

In addition to these which are peculiar to this district of Egypt, the action of wind and sand is particularly well seen. Here, as in the other parts of Egypt known to the writer, it is the wind from the south, south-west, and south-east (especially from the two former directions) which causes the sand to travel. There is however an exception in the case of the coast-plain to the north of Wadi Gharandel, where the north-east wind which sweeps down from Gebel el Ti often brings clouds of dust along with it.

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(\*) "Topog. and Geol. of Eastern Desert of Egypt, Central Portion," by T. Barron and W. F. Hume. Cairo, 1902.

1. *Rainstorms*.—Taking the agents in their order, the first to be described is the effect of the rainstorms. No one who has spent any time amongst the Bedawin of Sinai can have failed to be struck by the great care which these people take in choosing a camping place in the wadis. Nothing will induce them to camp in the bed of the wadi, even when the weather appears settled and the sky clear overhead, long experience having taught them how uncertain these appearances are, and how suddenly the storms break over the hills. In a few hours the peaceful appearance of the scene may be changed, and the dry valleys transformed into roaring torrents whose resistless might carries everything before it. Should any one have been foolhardy enough to encamp in the bed of the wadi he runs a good chance of being overwhelmed and carried away. Some idea of the resistless character of these storms may be obtained from an inspection of some of the wadi-beds after a storm. Deep cuts, some of them over 2 metres deep, have been made in the valley-floor, while boulders of enormous size have been dug out and carried down the wadi. On the sides of the wadis, too, marks may be seen about 8 metres above ground level indicating the height to which the water has risen, while uprooted bushes testify to the force of the current. A further witness to the great transporting power of the torrents is seen in the big deposits of boulders which lie like a fan at the mouths of some of the main wadis e.g. Wadi Hebrân and Emlaha.

2. *Frost and snow*.—These agents are only seen at work in the higher altitudes near the watershed, e.g., the upper part of Wadi el Sheikh and its tributary Wadi el Dêr, the granite massif of Gebel Musa and the neighbouring peaks, the high dolerite hill of Gebel Moreia, or the rugged range of Serbâl which overlooks the plain of El Qâ. On the north side of these hills in the winter months, hoar-frost can be seen throughout the day, the temperature never rising sufficiently to melt it. This condition continues for several days at a time, and there can be little doubt that the frost plays a great part in the disintegration of the rocks of these hills. On the surface of the gentler slopes a thin coating of disintegrated rock is seen which supports a few small plants while on the narrow ledges, and in the small nooks and cracks in the rock, a thicker deposit is seen in which grow luxuriant specimens of "Hamada" and other plants.

In the upper part of Wadi el Sheikh, during the survey carried out by the writer, temperatures up to  $-9^{\circ}\text{C}$ . were observed, and in the wadi the frost held sway through the entire day, the water-pools being covered by a thick sheet of ice. These conditions prevailed with varying

intensity for over a month, while snow was seen lying on the highest peaks of the watershed ranges for nearly two months. It follows therefore, that as the sun's heat increased, there would be alternate thawing and freezing which would tend to fracture, and finally detach pieces of the rock which would eventually be reduced to a fine powder by the continued action of these agents. Thus in this district, the action of frost, etc., ranks as one of the most important factors in the disintegration of the rocks.

3. *Action of moisture containing carbon dioxide.*—Coming to the last agent on the list, it may be regarded as the successor to the frost and snow, continuing and completing the work which the latter had begun. At the close of the winter the disintegrated rock acts as a covering to the surface of the rock, checking evaporation, and at the same time on account of its state of fine division acting as a sponge to absorb the dews which always form during the night in the higher regions. The seeds of plants of various kinds are borne by the wind and finally find a resting place in it, eventually germinating, flowering, and dying. In the autumn the annual rains fall, and as the temperature is sufficiently high to promote the rapid decomposition of the leaves and other parts of the plant into their ultimate components of carbonic acid gas and water, these are carried down to the surface of the rock and carry on the work of decomposition which the frost had commenced. In process of time the rock becomes decomposed for some distance from the surface, and the soil and loosened particles are carried off by the rain and deposited on the gentler slopes of the foothills and smaller wadis, eventually producing a soil of depth sufficient to carry fruit-trees from which the Bedawin annually obtain a crop of very fair quality, if the locust has not stripped the trees in early summer.

On the lower plateaux, where the slope is very small indeed, the disintegration of the rocks proceeds much more rapidly, especially where the country-rock is much cut up by basic dykes and intrusions. These yield much more rapidly to the weathering agents than the more acid country-rock and become reduced below the general level, forming a series of trenches towards which the rains naturally gravitate, thus hastening their decay even more rapidly. In numerous instances the gullies which seam the sides of the hills can be shown to be formed along the course of one of these dykes.

In the districts, too, where a basic gneiss forms the predominant rock of the district, the work of this agent is seen to great advantage. This rock, on account of its physical character, lends itself to rapid weathering,

its shear-planes allow of an easy passage of the moisture, while its constituent minerals having undergone deformation by the enormous force brought to bear on them, are in the most favourable condition for rapid disintegration by the agent under consideration.

The observed facts bear this out, for on the flanks of these hills quite a fair soil has formed, which in the spring-time is covered by a coat of verdure which furnishes abundant food to the large flocks of sheep and goats kept by the Bedawin. In the district nearer the sea-level, owing to the small rainfall and more seldom precipitation of dew, the action of this agent is practically nil, and insolation, change of temperature, etc., perform the work of disintegration.

In connection with this subject a paper published by J.G. Goodchild\* may be noticed. In it the author, in order to establish the point in his paper, has selected the Sinai Peninsula as an example on which to base his deductions. He states that wadis in all cases are the result of running water, a statement which the writer cannot admit, as numerous instances are known where they are the product of faults, subsequently used as a channel of drainage. It is a pity, that in selecting a typical example for his paper, the author did not choose a district of which he had personal knowledge, for, as far as can be learned from his writings he had his information from a series of photographs lent him by a friend. These, as is well known, are rather unsafe sources of information, and are capable of several interpretations according to the ideas of the different people who look at them. In these photographs the author evidently mistook the remains of the filling up of the wadis during a period of subsidence in Pleistocene times (as has been stated in the early part of this memoir), and put them down to screes. These he assumes are washed down by the thunderstorms and distributed over the wadi bed, over which dunes are later formed by the wind, they in turn, being levelled down by the torrents. He thus concludes that the wadis are being gradually filled up by the detritus. Unfortunately for the establishment of his hypothesis, evidence in its favour is entirely wanting, and instead of the heaping up of detrital materials in the wadis, numerous instances can be produced where the rocky bed of the wadi is exposed, while the throwing out of the water at different points along the drainage line testifies to the continuity of the rocky floor although it is somewhat uneven. It is only in these inequalities that any deposition has taken place and that ceases immediately the level of

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\* "Desert Conditions in Great Britain." Trans. of the Geol. Soc. of Glasgow, 1898, Vol. XI Pt I, p. 79 et seq.

the rocky protuberance is reached. If any deposition of detrital material takes place, it is at the mouth of the wadis where they debouch on the coastal plain, and the materials are spread out in a fan opposite each drainage line.

Although the action of sand and wind has been described at length in the Memoir on the Red Sea Hills, it is impossible to omit the mention of it here also, since there are such fine examples to be seen in this district. The plain of Debbet el Ramli owes its origin to the wearing action of the wind-borne sand, and the cliff of Gebel el Ti marks the progress of the work of attrition. At the base of this cliff lie boulders of the hard, crystalline limestone which forms the beds lying on the top, showing the result of the long continued scour of the sand. They are pitted all over, and the invisible cracks which traverse nearly every rock are brought out on the surface, their course being marked by furrows. These cracks evidently constitute planes of weakness as the rock is much more eroded where they occur. In the cliff itself, all the inequalities are planed off by the sand, and it presents the appearance of having been sand-papared down. In Gebel Dhalâl where the Nubian sandstone occupies the larger part of the cliff, this rock is worn out into hollows which are evidently eddies in a sandstorm, while the rock in general stands out in buttresses in a wonderful manner. The isolated masses of sandstone are worn and rounded off into conical hillocks which in the distance look like gigantic ant-hills. But in the centre of the plain the whole of the rock has been worn away and the ground covered with the sand piled up and held together to a certain extent by plants growing on it.

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# INDEX.

## A

**ABDAS PASHA**, 14, 37, 71, 72, 80, 83  
**Abcithiran** bushes, 68  
**Abiad, El**, plateau of, 33  
 —, **Gebel el**, 23, 32, 33-34, 124, 125, 129, 141, 150, 178  
 —, **Wadi el**, 23, 33-34, 124, 129, 141  
**Abu Alaqa, &c.** :—see **Alaqa, &c.**  
**Abu'aldi**, **Gebel**, 66, 67  
**Abûra**, **Wadi el**, 13, 22, 112, 113, 127, 141  
**Acacia Seyal** (or **Shittah**) :—see **Seyal trees**.  
**Acid granite rocks**, 184  
 — **rocks**, **black veins of** 61, 214  
**Adam**, **Gebel Um**, 33; **plateau of**, 34; 34, 125;  
**Eocene fossils from**, 130  
 —, **Wadi Um**, 33  
**Æolian action**, 159; **origin of rocks**, 160  
**African mountains**, 58; **hills**, 74; **North African fauna**, 108  
**Agrab**, **Gebel**, 178  
**Agraf**, **Wadi Um**, 45, 45, 46, 49, 49, 50, 183, 185, 193, 197, 202  
**Ahadha**, **Wadi el**, 36, 36  
**Ain**, **Wadi el**, 74  
**'Ajeleh**, **Wadi**, 54-56, 59  
**'Ajramiyeh**, **Gebel**, 6, 296 feet high, 67  
**Akhdar**, **En el**, 63, 64, 192, 195, 197  
 —, **Wadi el**, 45, 46, 51-53, 60-63, 102, 162, 180, 184, 188, 191-197  
**Alabaster pebbles**, (nodules), 149  
**Alaqa**, **Fersh Abu**, **plateau of**, 48, 194  
 —, **Gebel Abu**, 23, 24, 24; a **trigonometrical station of the Ordnance Survey**, 24; 38, 39, 108, 114; **geology of**, 115, 126, 145, 155, 157, 164; **fossils from**, 171; 172, 173, 177, 184  
**Alda shrubs**, resembling **arta**, 82  
**Aldi**, **Gebel Abu**, 67, 69  
**Alctron**, (*Nassa vel*), *glans*, 104  
**Alexandria**, 37  
**'Aleyat**, **Wadi**, 54-57, 59  
**Alhala**, **Gebel el**, a **small outlier**, 35  
**Alluvial deposit**, 54, 60, 78  
*Alveolina bosci*, 128

*Alveolina decipiens*, 128  
**Amâra**, **Gebel**, 34; **fossils from**, 120  
 —, **plain of**, 119-120  
 —, **Wadi**, 34; **path** (**Sikkat Amâra**) **from Wadi Silfa to**, 34; 34, 35, **fossils from**, 106; 106, **deposit at**, 107; **fossils from**, 120  
**Ammonites**, 138, 145  
 —, **large**, 149  
**Amphiope**, cf. *palpebrata*, 114, 122  
**Amphitheatre**, a **natural**, 73  
**Anadara**, 105  
 — *radiata*, 104  
**Analysis of hot springs**, 30; **of spring-water**, 135; **analyses of iron and manganese ores** by **A. Lucas**, **Chemist to the Survey Department**, 206, 206-207, 207-208; **analyses of manganese ores from Minas, Brazil**, 207-208; **of bone-beds**, 208; **of phosphatic nodules**, 208; **of celestine or strontium sulphate**, 209  
*Ancilla oralis* (= young of *A. cinnamomea*), 104  
**Andesitic basalt**, **beds of**, 117  
 — **dolerite**, 186, 192  
**Android**, the, 142  
**Animals**, various, 92  
*Anomalocardia holoserica*, 99  
**Anticlines**, 23, 31, 130, 141, 146, 165  
**Aqaba**, **road from El Watia pass to**, 65; **sand-stone near**, 850 feet thick, 155  
**Aqila**, **Gulf of**, 88  
 —, **Wadi Abu**, 42  
**Aqr**, **Wadi** :—see **Akhdar**.  
**Araba el Sogheira**, **Wadi el**, 19; **Wadi el Araba proper**, 19, 155  
**Araba**, **Gebel el**, 13-15, 18-21, 92, 100, 110-112, 122, 128, 130, 135-139, 153, 172, 173, 177-179, 183, 185, 189  
 —, **Wadi el**, 19, 20, 110, 112, 136, 137, 142, 153, 156, 157, 168, 169, 179, 183, 184, 190, 209  
**Arabia**, **hills of**, 74  
**Arabia Petraea**, **Russeger's geological map of**, 154-155  
**Arabs** :—see **Bedawin**.  
**Arca**, 106, 121  
 — *imbricata*, 104, 105

*Area indurata* (*Cucullæa Liguriensis* =), a cast like, 153  
 — *lactea*, 107  
 — sp., two forms, 104  
 — *squamosa*, 104  
 — *Tevsthenensis*?, 133  
 Archæan period, 204  
 —, Post-, period, 203  
 — rocks, 204  
*Arcopagia scobinata*, 105  
 Argillaceous :—see Clay.  
 'Aribeh, Gebel, (Gebel ed Deir or), 66  
 Arish, Wadi el, 35  
 Arremziyeh, Gebel, 67  
*Asaphis violaceus*, 99  
 Asfa, Gebel el :—see Asl.  
 Asfar, Gebel, 21 ; geology of, 112, 113, 115 ; and Wadi Geba, fossils from, 123 ; 127 ; geology of, 140 ; 141, 172, 174, 176  
 Asl, Gebel el, (or Asfa), 23, 142, 143, 172, 179  
 —, Wadi, 23  
 Asphodels, 52  
*Astarte amygdala*, 135  
 — *Fatma* ?, 133  
 — *Gabæ* ?, 133  
 — *obruta*, 132  
 — *pumica*, 132  
 — *subcordata*, 132  
*Astrocania*, 130  
 Aswan, 159, 183, 185  
 At el Gharbi :—see Gharbi.  
 Atâqa, Gebel, 102, 181  
 Atâtâr el Dhami, Gebel, 175, 176  
 Augite-diorite dykes, 193  
 — dolerite dykes, 196  
 Ayun Musa, 36, 37, 101, 102, 212  
 —, Wadi, 37

## B

BABA, Gebel, 45, 179  
 —, Séh, 41, 116, 121, 146  
 —, Wadi, 15-25, 41-44, 128, 146, 161, 163-169, 171, 174-176, 179, 180, 183, 192, 198, 202  
 Bagha, Wadi, 131, 150, 155, 159, 176, 198  
 Baghabug, Gebel, 79, 83  
 Bala, Wadi, 44 ; seyal trees in, 44  
*Balanus*, 99, 118  
 Ball, Dr., a fossil found by, 159  
 Ban trees, 55

Banât, Gebel el, 51, 52, 53, 54, 61, 188, 193, plateau of, 195 ; 202  
 Baqa, Wadi, 33, 34  
*Barbatia lima*, 104, 105  
 Barq, (Barraq or), Wadi :—see Barraq.  
 —, Séh, plain of, 48  
 Barra, Wadi, 53, 61, 62, 180, 188, 191, 197  
 Barracks, ruined :—see Buildings.  
 Barraq, (or Barq), Wadi, 48, 52, 180, 193, 194, 197, 201  
 Bartonian :—see Eocene, Upper.  
 Basalt, 17, 40, 41, 45, 147, 158, 160, 163-165, 170, 175, 178, 179, 183, 199, 200, 211  
 —, andesitic, beds of, 117  
 —, glassy, veins of, 146  
 —, melaphyre-, dark, 118  
 —, olivine-, beds of, (cap), 163  
 — tachylitic, black veins of, 198  
 Bashih, Wadi, 53  
 Basic beds, (segregation-patches), 186  
 — dykes, 183, comparative age of, 204 ; 214  
 — gneissose, rocks, 201, 214-215  
 — rocks, (ultra-basic), 196, 200  
 Basal, Wadi Um, 47 ; a path from, to Wadi Entish, 47  
 Baths, medicinal, near El Tor, supplied by hot springs, 18-19  
 Batn el Araba, ridges of, 19  
 —, Gebel, 190  
 Bauerman, 95, 108, 131, 132, 148, 149, 155, 161, 161, 166, 167, 171, 183, 211  
 Beach, (shore), 93, 100, 146  
 — deposits, 26 ; ridges of, 38 ; 115, 147, patches of, 149-150 ; 150, 151-152, 152, 156, 177, 180, 182  
 — —, Miocene, 147, 200  
 — —, Pleistocene, 182  
 — plateau, between Gharandel and Suez, 33-37 ; area, 38  
 Beaches, crystalline limestone, 110  
 —, gravelly, 25  
 —, limestone, 32, 34, 35, 101, 119, 120  
 —, raised, 15 ; a strip of beach, 20 ; area of, 36, 98 ; 102, 109, 182  
 —, recent, a younger, 99, 101, 109  
 Beans, cultivated by the Bedawin, 32  
 Bêda, Wadi, 17, 43  
 Bedawin, 14, 16, 17, 19, 21, 22, 27, 30-34, 36, 37, 39, 40, 42-44, 48, 50, 52-54, 59, 61-65, 67, 70, 71, 75-78, 82, 83, 85, 87, 92, 110, 209, 210, 212-215

Bedding, current-, 89, 116  
 —, false-, 97, 160  
 Bêdhat Um Takha, conical peak of, 62, 77, 188  
 Benat, Gebel el, a magnificent view from, 56  
 Berq, Wadi, 47  
 Bey, Figari, description of sandstone in Egypt,  
 &c., by, 155 (and note), 161  
*Bigennerina nodosaria* ?, 128  
 Binary granite, white, veins of, 193  
 "Binnensee," a salt, 107  
 Biotite, 185, 203  
 — -gneiss, fine and coarse, 202; comparative  
 age of, 203  
 — -granite, grey, 195; comparative age of,  
 203  
 — — rocks, grey, 187  
 Bir Dhafâri :—see Dhafâri.  
 Bir, Wadi Abu, a small wadi, 88  
 Birds, 60, 92  
 Biahër, Gebel Sin, 36, 125, 150  
 Biyut, Wadi, 49  
 Blanckenhorn, 95, 106-108, 117, 118, 125, 144,  
 171, 172, 180  
*Bolivina punctata* ?, 126  
 Bone bed, 206  
 Bosses, granite, 40; red, 51, 62, 192  
 —, porphyritic granite, 192; knob, 192  
 —, — quartz-felsite, 197  
 —, quartz-felsite, 194, 197  
 —, syenite, 52, 195  
 Botany of Sinai, 91  
*Botula*, (*Lithodomus* vel), *cinnamomea*, 107, 121  
 Boulder-conglomerate, 117  
 Boulders, 14, 16, 21, 27, 28, 32, 35, 37-39, 42,  
 49, 52-56, 61, 71, 75-77, 80, 82, 84-86, 88,  
 96, 97, 99, 102, 108, 129, 186, 189, 213, 216  
 Bowwal plants, 35, 36, 86  
*Brachiopoda*, beds of, 167, 168  
 Branner, Professor J. C., 207  
 Breccia, fine, 99, 99, 169  
 —, nummulitic limestone, 118  
*Bryozoa*, 101, 130, 168  
 Bsilla plants, 87, 90  
 Budra, Gebel Naqb, 41, 131  
 —, Naqb, pass of, 16, 41, 133, 145, 154, 157  
 —, Wadi Naqb, 38, 40-42, 116, 132, 135, 145,  
 154, 157, 164, 165, 192  
 Bugiyeh, Wadi, 70  
 Buildings, (quarantine at Qrum), 15; at Ayun  
 Musa, 37; monastic, 70; ruined barracks,  
 72; monastic, 75, 77.—See also Houses.  
*Bulla ampulla*, 104

Bulrushes, 31, 60, 80, 83, 86  
 Bum, Wadi, 47, 62, 192  
 Burckhardt, ascent of Gebel Serbâl by, 57, 58  
 Burial-grounds : an Arab cemetery, 43; Beda-  
 win, 59, 63, 65; burial-place of the Tables of  
 the Law, 73.—See also Tombs.  
 Buwêb, El, (or the gate of Ferân), 60

## C

CAIRO, 37, 181, 204  
 Calcareous bods, 108, 114, 115, 124, 148  
 — cement, 96, 101, 109, 117  
 — grit, 112, 113, 115  
 — limestone, 114  
 — matter, 34, 35, 101, 107, 120  
 — sand, beds of, 119  
 — sandstone, 101, 108, yellow, 109, 112, 113,  
 hard, 119; 136, 149  
 Calcite, 189  
*Callista erycina*, 123  
 — *suberycinoides*, 130  
 Camel-drivers, 28  
 Camel tracks :—see Roads.  
 Camels, 27-29, 41, 45, 52, 53, 60, 64, 70, 71, 85,  
 92  
 Camps, 68, 88, 92, 213  
*Canarium dentatum*, var. *erythrinum*, 104  
 — *gibberulum*, 104  
*Capiluna Ruppelli*, 103  
 — —, var. *Barroni*, 103, 105  
 Carbon dioxide, 214-215  
 Carbonate, lime of, 98  
 Carboniferous beds, 42, 44, 95, 146, 148, 154,  
 155, 157, 159, 160-171, 175, 176-179, 185,  
 186, 192-194, 198, 199, 201-205, 210  
*Carcharodon megalodon*, numerous teeth of,  
 107, 120, 121  
*Cardita*, 132  
 — *angisulcata*, 105  
 — *calyculata*, 104, 105  
*Cardium*, 106, 109, 121  
 — *leucostoma*, 105  
 —, cf. *maculosum*, 105  
*Carolia placunoides*, 130  
 Cataracts, 42; 100 metres high, 42; agency of,  
 78; 82; the first, at Aswan, 183.—See also  
 Water-falls  
 Caves, (or galleries) : in Wadi Nasb, 44; con-  
 taining Sinaitic inscriptions, near El Ma-  
 dhawwa, 58; 60; cave of Moses, according  
 to the Arab tradition, on Gebel Musa, 67;

- cells on and around Gebel Musa, 70; a rock grotto, 71; cave of Korah, Dathan, and Abiram, 73; ruined monastic cells, 78; rock grottoes, 81
- Celestine, (or strontium sulphate), veins of, 107, 120; and analysis of, 209
- Cellepora*, 121
- , cf. *palmeta*, 122
- Cement, calcareous, 96, 101, 109, 117
- , lime-, 37, 116
- , silica-, 162
- Cemeteries: Arab, 43; Bedawin, 59, 63, 65; burial-place of the Tables of the Law, 73.
- See also Tombs.
- Cenomanian beds, 119, 132-135, 151, 160, 161
- Cerastes*, one, killed, the only venomous snake seen, 92
- Cerithidea palustris*, 99
- Cerithium caeruleum*, 104
- *conicum*, 107
- *erythraeonense*, (= *tuberosum*), 104, 105
- *Ruppelli*, 104
- Chalky beds, 33, 149
- Cretaceous rocks, 152
- limestone, 125, 140, 142, 151
- Chama Jukesi*, 105
- *nivalis*, 105
- Chapels, 67, 70, 71, 72, 74
- Chapman, *Foraminifera* determined by, 124, 125, 126; *Nummulites* recognised by, 127; *Foraminifera* recognised by, 128; fossils recognised by, 129
- Chasms, 72-75, 77, 81
- Chats, numerous, met with in all the wadis, 92
- Chicoreus anguliferus*, 104
- Chione costellifera*, 105
- Chlorite, 149
- Chonetes*, 166, 167, beds of, 167; 168
- Cidaris avenionensis*, spines and plate of, 107, spines of, 121
- Circe corrugata*, 105
- *pectinata*, 105
- Circles, stone, in Wadi Nisrin, 50
- Clanculus Pharaonicus*, 103
- Clay, 14, 15, 25, 32, 35, 37, 62, 96-103, 108, 113, 116, 118, 136, 157, 158
- Clefts, 72-75; a deep chasm, 77; a narrow chasm, 81
- Cliffs, 18, 27, 29, 30, 32, 33, 40, 42, 44, 47, 56, 59-61, 68, 70-73, 76, 80, 81, 84, 86, 92, 128, 137, 142, 146, 148, 150, 157, 159, 164, 168, 189, 200, 210, 216
- Cliffs, Carboniferous sandstone, 44
- , Cretaceous gypsified, 151
- , — limestone, 26, 143
- , gneiss, 59
- , granite, grey, 59, 59, 77, 86
- , greenstone, 59
- , gritty limestone, 31
- , gypsum, 34
- , limestone, 27, 29, 35, 46, 137
- , mica-schist, 59
- , porphyritic quartz-felsite, 63
- , quartz-felsite, 48
- , sandstone, soft, 39, 40, 43
- , Upper Cretaceous flinty limestone, 147
- Cloudy days, 91
- Clypeaster plancunarius*, 99, 105
- *subplancunarius*, 120
- aff. *subplancunarius* (sp. nov.), 106
- Clypeaster sands, near Giza Pyramids, shells from, 180
- Coast-plains, 31, 35, 87, 92; geology of, 97-99; 102, 156, 186, 212, 216
- ranges, 21, 58, 135, 144, 150, 156, 183, 190, 196
- ranges, igneous, 155, 173, 179
- region, 174
- See also Beach.
- Codakia exasperata*, 105
- *fibula*, 105
- *Fischeriana*, 105
- Calopeurus*?, 121
- Caloria arabica*, 106
- Columbella flava*, 104
- Conformity, 161.—See also Unconformity.
- Conglomerate, 25, reddish, 26; 32, brown, 33; 34, 37, 110, 112, 113, 114, 116, coarse, 118; 169, 170, 182
- , beds of, 101, 110, 117, 128
- , boulder-, 117
- , Cretaceous limestone, 117
- , deposit of, 101
- , flint, 101, 114, 116, 117, 118, 178
- , —, beds of, 24, 108
- , —, pebbles, of, 113
- , —, ridge of, 27
- , flinty limestone pebbles, of, 111, 112
- , gravel-, 36, 96
- , gypsous, 34
- , hills of, 23, 26, 30
- , limestone pebbles, of, 115, 116
- , nummulitic limestone pebbles, of, 111-114, 128

Conglomerate, quartzite pebbles, of, 162  
*Conodypeus conoideus*, 130  
Consular agencies, at El Tor, for Russia and Germany, 15  
Continental period, 160, 170  
*Conus*, 104, casts of, 119  
— *arenatus*, 104  
— *erythraeensis*, 104  
— *monachus*, 105  
Convent, at Gebel Musa, road from Suez to, 17; of St. Katharine, 66, 70, 71; ruins of two convents, 70; of El Arbain, 72; 76; a so-called, remains of, 78.—*See also* Monastic buildings.  
— valley, the, 67  
Copper, small pieces of, 108  
— mines, old workings, in Wadi Nasb, 44; in Wadi Malha, 166; in Wadi Halliq, 167, 206  
— ore, in Wadi Nasb, 44; in Wadi Malha, 166; in Wadi Halliq, 167, 206; in Wadi Nasb, 206; in slag on Gebel Safariat, 208  
— slag, heaps of, in Wadi Nasb, 44; on Gebel Safariat; also containing manganese, 208  
— smelting area, 167  
Copolite beds, 140  
Copolites, phosphatic nodules resembling, and analysis of, 208  
*Coptophyma problematicum*, 153  
Coral, 32; dark, 34; fossil-, 97; reef-building, in the sea, masses of, 98; 99, fragments of, 99; 107, 108, imperfect, 109; 110, much altered, 110; 111, imperfect, 111; 112, 113, 114, imperfect, 115, 117; casts of, 120; 127, 140, 168, 169  
—, crystalline, rocks of, 35  
— limestone, 19, 108, 114  
—, beds of, small masses, 97, 110  
— reefs, 89, 99, 134, 155  
*Corbis*, 122  
*Corbula*, 106, 121  
— *revoluta*, 107, 121  
*Crassatella*, cf. *Falconieri*, 134  
Cretaceous beds, 23, 26, 28, 38, 41, 95, 96, 109, 110, 112, 115, 117, 123–129, 131–157, 159–161, 168–170, 172–179, 198–200, 204, 208  
*Crinoids*, and stems of, 167; bed of, 167; stems of, 168, 169  
Crocuses, 62, 63  
Crystalline beds, 116, 140; of dark amethyst colour, 148; 166, 167

Crystalline coral rocks, 35  
— gritty limestone, 167  
— limestone, 28, 111, 112, 114, 129, 138, 139, 140; recrystallised, 151; dark, 166, 167, 168, 202  
— beach, 110  
— limestone, beds, 166, 203  
— boulders, 216  
— marly limestone, 140, 158  
— rocks, 25, 27, 167  
Crystals, gypsum, 151, 152  
*Cucullaea Ligeriensis* (= *Arca indurata*), a cast like, 155  
*Cularis Avenionensis*, spine of, 121  
*Cyphastraea chalcidicum*, 105, 107  
*Cyphosoma*, 149  
*Cypraea*, 107, 121  
— *erosa*, 103  
— *turdus*, 103

## D

DAMA, Wadi, 50  
Danian, 129, 137, 147, 151  
Darba, Gebel Abu, a landmark for navigators, 20; a high conical hill, 189; 190  
—, Wadi Abu, 34  
Darqid, Wadi, 51, water in the wadis of, 51; hamad and asphodels in, 52  
Dates, 15, 22, 76  
Dead Sea, tectonics of, 183–184  
Debbet el Ramli, plain of, 16, 17, 27, 28, 38, 43, 44, 90, 91, 92, 158, 162–164, 167, 178, 185, 198, 199, 216  
Dehësa, Wadi, 36, 101  
Deir el Arbain, 72, 74  
—, Gebel ed, 66, 70  
—, Wadi ed, 66, 68–72  
— *See also* Dër.  
Delta, a, of débris, 16  
Demara (?), Wadi Um, 35  
Dëmat, Gebel Abu, a flat-topped hill, 28; road over flank of, 28; 28, 117, 148, 148, 159; plateau of, 175  
*Dentalium octagonum*, 104, 105  
Denudation, 17, 18, 35, 49, 52, 129, 144, 149, 151, 158, 162, 179, 181, 186, 199, 201, 204, 212–216  
— *See also* Weathering.  
Depth :—*see* Height.

Dér, Gebel el, 65

—, Wadi el, 17, road from Suez to, 17, 48, 62, 64; road from, to Ras Safsâfa, 65; 66, 213

*See also* Deir.

"Desert sandstone," 162, 170

Desert, the, 60, 69, 74, 78, 81; Eastern, red granite in, 185; Eastern, 187

"Devonian sandstone," 170

Dhabb, Fersh el, 76, 80

Dhabba, Wadi Mas el, 35

Dhafâri, Bir, a well near Gebel Markhâ, 16

Dhalâl, Gebel, 38, 45, 46, 47, 63, 148, 155; geology of, 157-158; sandstone of, 159; watershed at, 160; 178, 205, 216

Dhenb, Wadi, 52

Diabasic dykes, 188

Diorite, 82, 89, 134, 182, 192, 193, 195, 203, 204

—, augite-, dykes of, 193

—, dykes, 196

—, micaceous, bed of, patch, 195

—, quartz-, 192, 195

—, quartz-, hills of, 187

—, quartz-felsite, 186

Dioxide, carbon-, 214-215

Dip, 17, 25, 100, 108, 109, 110-119, 124-128,

" 136-150, 155-157, 159, 164-165, 167, 172-174; hade, 176; 176; hade, 177-178, 179; 202, 210

*Diplodonta*, cf. *rotundata*, 123

*Diplopodia* ?, 153

— *sinaicum* ?, 154

— *variolare*, 154

— — — ?, 153

*Discoidea Forgemolli*, 132, 133

— *subucula*, 132, 133

*Discorbina globularis*, 126

— *rugosa*, 126

Dislocation, 18; shift of rocks, 21; of strata, 21; displacement of beds, 111, 150; displacement, 173, 176, 178

*Divaricella ornata*, 105

—, cf. *ornata*, 123

Dolerite, 51, 84, 89, 99, 186, 187, 189, 190, 193, 196, 197, 200, 201, 204, 213

—, andesitic, 186, 192

—, augite-, dykes of, 196

—, dykes, 82, 146, 147, 163, 168, 186-192, 195-198, 201, 204

—, necks, 79, 83, 84, 187, 187-188, 196, 204

—, porphyritic, dykes of, 189

*Dolium pomum*, 105

Dolomite-limestone, 109 (and note)

Domes, 189, 190, 191, 204

—, granite, 57, 72, 185, 191

Donkeys of the Bedawin, 64, 85

*Dosinia amphidesmoides*, 99

Downwash, 33, 34, 100, 109, 110.—*See also* Deposits.

Dragon-flies, 81, 85

Drainage area, basin-shaped, 85

— systems, 13, 16, 17, 18, diverted, apparently by a dip-fault, 20; 20, 21, 24, 25, 26, 27, 29, 31, 33, 34, 35, 38, 43, 44, 45, 46, 47, 48, 50, 52, a drainage line, 52-53; 54, 55, 60, 63, 64, 66, an important drainage line, 80; 81, 84, 85, 86, 87, 88, 89, lateral, the result of an earth movement, 90; before the, 103; 110, determined by a fold, 139; 168, determined by a fold, 174, by a roll, 174; of Wadi Baba, 174; a side drainage, 175; of Shellâl and Baba, 175; east and west, &c., 180; 187, 188; drainage line, 193; 195; drainage way, 199; 215; drainage line, 215, 216

Duncan, the late Dr. P. M., F.R.S., fossils named by, 131; conclusions by, 132, 151

Dunes, 215

—, sand, 21, a large, 90

Dyke area, 75

— ridges, dyke-centred granite, 75

Dykes, 25, 26, 27, 47, many, 48; a hard, 51; and veins, hundreds of, 51; 52, very numerous, 59; many, 61; dyke system, 75; black, 77; 80, black, (= giddet), 83; direction of, probably determined by lines of fold or fracture, 90; 150, 185, compound, 186; numerous, 187; 188, 189, becoming gullies, 189; and veins, 195-198; 195, out to ribbons by, 196, and veins, 196; and veins, 198; 200, numerous, 202; and veins, 209

—, augite-dolerite, 196

—, basic, 183, comparative age of, 204; 214

—, diabasic, 188

—, diorite, 196

—, dolerite, 82, 146, 147, 163, 168, 186-198, 201, 204

—, felsite, red, 61, 193, 197, 201

—, felsophyre, 188

—, glassy felsite, 188

—, gneissose quartz-felsite, 197

—, granite, red, 191; fine, 194; red, 196; fine, 197; 204

—, granophyre, 191

—, micro-granite, 193, 196

- Dykes, porphyritic dolerite, 189  
 —, — quartz-felsite, 105, 197  
 —, quartz-felsite, 82, 186, coarse, 186; 187,  
 190, 192, 193, 194, 195, fine-grained, 196;  
 196-197, comparative age of, 204  
 —, spherulitic felsite, 188  
 —, syenite-felsite, 196  
 —, tachylitic, 147, 198

## E

- EAGLES, 92  
 Earth movements, 18; lateral drainage the  
 result of an, 90; 111, 113, 210  
*Echinids*, 99, 107, 111, 112, 114, 115, 120, 125,  
 138, 145, 148  
*Echinocyamus*, cf. *Studeri*, 120  
*Echinoderms*, spines of, 120, 126, 127, 140, 142  
*Echinolampas*, 129  
 — ?, 116  
 — *amplus*, 121  
 — *Crameri*, 130  
 Ed Deir :—see Deir.  
 Egypt, Russeger's geological map of, 154; sand-  
 stones in, described by Figari Bey, 155 (and  
 note); formerly connected to Sinai, 182; this  
 district and other parts of, 212  
 "Egypt, Topography and Geology of the  
 Eastern Desert of, Central Portion," 151, 180  
 Egyptian sandstones, 155  
 Egyptians, ancient, 166, turquoise working by,  
 169, 209 (and note)  
 Ekba, Gebel, 52  
 —, Wadi, 52  
 Ekmi, Gebel, 23, 114  
 El Araba, &c. :—see Araba, &c.  
 Elevation of land, 100, 181, 182  
 Elwi el Agramia, Fersh, plateau of, 17, 63, road  
 from Wadi Hamanier to, 63; 64, 65, 102  
 —, Gebel el, 187  
*Emarginula incisura*, 103  
 Emlaha, Gebel, 187  
 —, Wadi, 79, 80, 86, 96, 97, 187, 190, 192,  
 195, 205, 213  
 Emleaa, Wadi, 75-76  
 En Awara; En el Akhdar :—see Awara;  
 Akhdar.  
 Engawa, Naqb el, 76, 77, 78, 79, 191  
 Enqaib, Wadi, 47  
 Enqi el Fûl :—see Fûl.  
 Entish, Wadi, 47, 48, 180, 194

- Eocene beds, 95, 108, 110, 112, 116, 121, 123-  
 130, 134, 139, 140, 149-152, 159, 173-178,  
 181, 204  
*Epiaster distinctus*, 131, 133  
 — *minimus*, 133  
 — *tumidus*, 131, 133  
 Er Rahab, &c. :—see Rahab, &c.  
 Erosion :—see Denudation.  
 Erthama, Wadi, a spring of good water in, 62  
 Erwès el Ebèriq, plain of, 61-62  
 Erythraean area, 107  
 — fauna, 181; genera and species, 182  
 Es Sho'eib :—see Sho'eib.  
 Esba, Wadi, fossils from, 154  
 Escarpments, 20, 24, 25, 28, 34, 35, 46, 110, 111,  
 136, 138, 140, 140-144, 146, 168, 179, 194, 199  
 —, Cretaceous limestone, 146  
 —, flinty limestone, 25  
 —, gritty limestone, 29  
 —, limestone, 22, 23, a coastal ?, 109; 146  
 149  
 —, marl, 22, 137, 143  
 —, sandstone, red, 22; due to the action of  
 wind, 90  
 Esh, Wadi el, 47, 61, 62, 192  
 Esna shales, absence of, 129  
 Esnân, Gebel Um, 77, 191, 203  
 Et Tahuneh, &c. :—see Tahuneh, &c.  
 Ethâl, Wadi Ras, 26-30, 33, 93, 107, 108, 118,  
 119, 125, 147-150, 154, 155, 173, 175, 176, 179  
 Ethmed, Gebel, 76  
 —, Wadi, 79  
*Eulima*, 161  
*Exogyra flabellata*, 135, 136  
 — *Mermeti*, 136  
 — *disiponensis* (vel *Overwegi*), 131 (and note),  
 132 (and note)  
 — *plicata*, 131, 132

## F

- FALCONS, Peregrine, 92  
*Fasciolaria polygonoides*, 104  
 Faults, 18, 20, 25, 27, 28, 31, 39, 41, 43, 87,  
 90, 95, 100, 110-117, 124-128, 135, 137-150,  
 152, 155-157, 159, 161, 164-182, 185, 187,  
 192, 199, 200, 202-204, 209-211, 214, 215  
 — dip-, 20, 111, 137, 150, 156, 172-179  
 — step-, 41, 137, 144, 172-179  
 — strike-, 111, 150, 172-179  
 — trough-, 148, 172-179, 199

- Fauna**, North African, 108; of the Indian Ocean, 181; Mediterranean and Erythraean, 182;  
Erythraean genera and species, 182
- Fêh**, Gebel Um, 50  
—, Wadi Um, 49-50, 50
- Felsite**, red, 51, 61, 89, fluidal, 193; 195, 196, 197, 201  
—, diorite-quartz-, 186  
—, dykes, 61, 82, 186-188, 190, 192-197, 201, 204  
—, glassy, 188, 196  
—, gneissose quartz-, 197  
—, porphyritic quartz-, 63, 195, 197  
—, quartz-, 48, 51, 60, 82, 89, 99, 186-188, 190, 192-197, 204  
—, schistose, rocks of, (quartz-schiefer), 201  
—, spherulitic, 188, 189  
—, syenite-, 188, 196, 204
- Felsophyre**, veins of, 188  
—, dykes, 188
- Felspar**, white, 51; pieces of, 97; 195.  
resembling orthoclase, 196; very large, 197;  
large, 201; white, bands of, 202; 203  
—, orthoclase-, pink, 189  
—, porphyritic, 185, 186, 195
- Fera'**, Gebel, 66, low ridge of, 69
- Ferân**, gate of, (El Buwêb or), 60  
—, oasis of, 54, 59, 60, 102, 103, 197, 202  
—, pass of, 59-60  
—, Wadi, 13, 16, 20-25, 38, 48, 50, 51, 53-56, 59, 61, 64, 77, 100, 102, 103, 110, 112-116, 122, 126, 127, 131, 138, 139, 142-145, 151, 155, 156, 172-177, 183, 184, 189, 193, 196, 202
- Ferns**, 75, 78, 81, 85
- Ferruginous beds**, 136  
—, gravel, slag-like, 41  
—, limestone, 136  
—, pebbles, (nodules), 162  
—, sandstone, dark, 165  
—, sandy bed, 149  
*See also* Ferric; and Iron.
- Fersh Abu Loz**; el Dhabb, &c.:—*see* Loz, Dhabb, &c.
- Fershes**, (= plateaux), 73, 194
- Ficula condita**, 118
- Fig trees**, wild, 64, 75, (or hammad), 85
- Fili**, Wadi Ibn el, 35
- Fish**, teeth of, (shark's teeth), 120, 126, 140
- Flint**, 99, 100, 111, 112, 116-119, 129, 136, 138, 140, 142, 149  
—, conglomerate, 24, 27, 101, 108, 113, 114, 116, 117, 118, 178
- Flinty limestone**, 25, 30, 111, 112, 142, 144, 147, 151, 174
- Flocks of the Bedawin**, 17, 44, 53, 61, 64, 65, 76, 87, 215. *See also* Goats; and Sheep.
- Floods**:—*see* Torrents.
- Flowers**, 38, 49, 59, 91
- Fluvio-marine action**, 159
- Folds**, 51, 90, 127, 139, 141, 147, 150, 156, 165, 172-174, 176, 180, 202, 203, 209, 211
- Forage**:—*see* Vegetation.
- Foraminifera**, 108, Lower Eocene, (or Libyan), 116, 124, small, 125; 125, 126, 128, a bed of, 129; 138, 142
- Foraminiferal limestone**, 116  
—, blocks of, 124
- Fossils**: fossil-coral, 97; lists of, 103-106; indications respecting, by Dr. Blanckenhorn, 106; Mediterranean characters of, 106; from Wadi Amâra, 106: from Gebel Zietî, 106-107; Blanckenhorn's remarks on, 107; Mediterranean forms of, 107; from Wadi Ethâl and Gebel Khadêd el Dhib, 107; a Mediterranean form of *Ostrea*, 107; 107, of 2nd and 3rd Mediterranean forms, 107; 113, 116, 118, collected by Rothpletz, 119; 119, 129, lists of, 131, 133; without 144-145, 148, 152; 161; collected by Hull, 162; from near Wadi Meringa, 166; collected by Walther, 168, by Rothpletz, 168 (and note)
- Fossils**, Carboniferous, lists of, 171  
—, Cenomanian, 132, lists of, 135; 160  
—, Cretaceous, lists of, 131-135, 152, lists of, 153-154  
—, Eocene, 121, lists of, 130  
—, Lower Eocene, (or Libyan), foraminifera, 116  
—, Miocene, Pliocene and, 106-123, 106, 108-123, lists of, 120-123; Pliocene and, 180  
—, Pleistocene, 98, Late to Recent, 99  
—, Pliocene, and Miocene, 106-123, 106, 106-108, and Miocene, 180  
—, Post-Pliocene, lists of, 103-106  
—, Post-Tertiary, of Western Sinai, 103-106  
—, Tortonian, 106
- Foster**, Le Neve, 95, 132, 148, 149
- Fourtau**, 98, 123, 134, 135, 143, 144, 159, 160, 172, 173
- Fraas**, a well-known geologist, 95
- Frost**, hoar-, 91; and snow, effects of, 213-214; hoar-frost on the hills, 213; 213-214

Fruit, large gardens of, 37; of the sidr tree, (nebk), 59; groves of, 70; -trees, numerous, 76; -trees, 214

Fûl, Enqi el, 32

*Fungia patella*, var. *lobulata*, 105

Fur'eiah, Deyest, 66, 67, 70, 71

—, Gebel el, 66

Fus, Wadi Um. 53, 54, 57

## G

Ga'ah, El, 58, 81

Gabari, Wadi el, 53

*Galaxea irregularis*, 106

Gallâlâ, Gebel, 181

Gallam, Wadi Abu, 142

Gangue, 206-207.—See also Orez.

Ganûs, Wadi, 52

Gardens, 15, 18, 31, 37, 44, 50, 60, 63, 70, 71, 75, 76, 78, 82

Garf, Wadi, 17, 44, 158

Garnet, abundant, 103

Garnetiferous rocks, 202, 203

*Gasteropoda*, 98, 109; imperfect casts of, 115; 119, 127, 158, 168

*Gastrochana Retzi*, 107

Gatâr, Gebel Abu, 190

Gatih, Gebel Um. 186

—, Wadi Um, 88

Gazelles seen only once or twice, 92

Geba, Gebel, 81, 190, 196

—, Wadi, 13, 21, 22, 81, 90, 113, 123, 190

Gebel Abiad, &c. :—see Abiad, &c.

Gebèle, fishing village of, 14, 15, 98, 109

Gehân, Ras, 190

Geological map, (by Blanckenhorn), 117-118; of the Ordnance Survey, 123; by Hull, 123; by Rev. F. W. Holland, 131; by Hull, 134 (and note); by Walther, 141; maps by Russeger, 154-155; by Walther, 156; by Hull, 160; maps by Russeger, 161; by Hull, 170; maps, deductions from, by Blanckenhorn, 171 (and note); 172, 173; by Russeger, 182; 203

— sections, 65, 99; sequence, 109, 111-120, 124, 129, 136, 138, 140, 142, 148-149, section IV, 150; 156, 158, 162-163, 166, 167, 168; sections, 176; section III, 177; VI, 179; across the Peninsula, 183; sequence of rocks, 201; table of rocks, in order of their age, 203-204

Geologists, 95, 106, 151, 189, 201

German petrologists, 201

Germany, consular agency for, at El Tor, 15

Ghadir, Wadi el, (or Satakh), 61, 193

Gharandel, Wadi, 29, 31-37, 92, 93, 108, 116, 125, 150, 174, 212

Gharbi, Gebel Ât el, 46, 63, 65, 75, 89, 102, 186, 187, 191

—, Wadi Ât el, (or Gharbeh), 47, 75, 89, 92, 97, 102, 192, 196

Gharib Lighthouse, 98

Gharqad bushes, 14, 15, 29, 31, 32, 32, 99

Ghub, Gebel, 19, 190

—, Wadi, 82

Giddet el Ela, Gebel, 83, 84, 85, 85-86, 187, 196

*Gigantopecten latissimus*, 121

Girgir, Wadi, 87, 88, 97

Girsum, Wadi Um, a spring near, 70

Giza Pyramids, 180

Glass, manufacture of, sandstone suitable for, 205

Glassy basalt, veins of, 146

— felsite, veins of, 188

— — — dykes, 188

— quartz-felsite, 196

Glazes, 208

*Globigerina bulloides*, 124, 126

— *conglobata*, 126

— *cretacea* ?, 126, 128

Glomero-porphyrific beds, patches, 189, 197

*Glycymeris Marrotianus*, a cast like, 153

— *pectunculus*, 105

— *pilosus*, 123

— sp. nov. ?, 123

Gneiss, 15, 16, 23, 38, 41-45, 47, 49-51, 53, 59, 61, 63, 64, 76, 77, 79, 80, 127, 143, 156, 157, 161, 166, 167, 170, 175, 183, 188, 190-194, 196, 197, 201-204

— biotite-, 202, 203

—, micaceous, 195

Gneissose basic rocks, 201, 214-215

— granite, 51, 61, 63, 193, 194, 195, 202-203

— gravel beds, floor, 50, 51

— quartz-felsite dykes, 197

Goats of the Bedawin, 17, 53, 64, 70, 85, 87, 215.

—See also Flocks.

*Goniastrea favus*, 105, 106

Goodechild, J. G., 215-216 (and note)

Gorf, Wadi Abu, 87

Gorges, 18, 19, 21, 29, 38, 39, 42, 57, 65, 75, 75, 80

—, diorite, 82

—, granite, 89

Goze, Gebel, 51, 61, 188, 202  
 Gran Atûd, Gebel, 187  
 Granite, 14, 16, 20, 21, 24, 27, 38-43, 45, 47, 49-53, 55, 57, 59, 62, 64-66, 68, 71, 72, 75, 77, 79-83, 86, 87, 89, 96-99, 135, 143, 164, 165, 167, 168, 175, 183-187, 189-192, 197, 199-201, 213  
 —, acid, 184  
 —, Aswan, 185  
 —, binary, 193  
 —, biotite-, 187, 195, 203  
 —, dykes, 191, 193, 194, 196, 197  
 —, gneissose, 51, 61, 63, 193-195, 202, 203  
 —, green, 67  
 —, grey, 47, 61, 64, 67, 79, 81, 186-195, 202-205  
 —, hornblende-, 180  
 —, micaceous, 191, 193  
 —, micro-, 193, 196  
 —, pink, 38, 62, 66, 73, 75, 80, 81, 185, 186, 188-195, 197, 202-204  
 —, porphyritic-, 185, 186, 188-192, 197, 203, 204  
 —, red, 16, 19, 42, 50, 52, 61, 62, 66, 67, 73, 75, 87, 89, 185-196, 201, 204  
 —, syenitic, 66, 73, 74  
 —, white, 80, 82  
 Granophyre, 189-191  
 Grasses, 59, 70  
 Grasshoppers, 81  
 Gravel, 13, 15, 17, 24-27, 30-32, 34-36, 60, 65, 81, 96, 99-102, 107, 108, 113, 115, 156, 181  
 —, conglomerate, 36, 96  
 —, ferruginous, 41  
 —, gneissose, beds of, floor, 50, 51  
 —, granite-, 68  
 —, igneous, 16, 97, 109  
 —, limestone-, 16, 99  
 Greek traders, 37; chapel, a, 67  
 Greenstone cliffs, 59  
 Grit, 28, 36, 37, 109, 112, 115, 116, 162, 168, 170  
 —, calcareous, 112, 115, 115  
 —, ochreous, 151  
 Gritty calcareous sandstone, 113  
 —, crystalline limestone, 167  
 —, limestone, 28, 29, 31, 108, 113  
 —, rock, 109  
 —, sandstone beds, 97  
 Grottoes :—see Caves.  
 Groves, 59, 60, fruit-, 70.—See also Palm trees; and Tarfa trees.  
 Gryphæa beds, 124, 127, 140, 141, 143-145, 147-149, 152, 175, 177, 178

*Gryphæa vesicularis*, 151  
 — — —, var. *judaica*, (*vesiculosa* =), 136, 140, 142  
 — *vesiculosa*, (= *vesicularis*, var. *judaica*), 153  
 Gudies, Bedawin, 30, 50, 57, 78, 210, 211  
 Gullies, 33, 40, 43, 47, 52, 53, 56, 82, 86-88, 138; formed from dykes, 189; 191, 196, 213, 214  
 Gurdi, Wadi Abu, 22, 141, 177  
 Gushia, Gebel, 32, 119, 150  
 —, Wadi, 32  
 Gypsum, 14, 15, 21, 24, 25, 29, 32, 34, 35, 38, 101, 107, 108, 113-116, 118-120, 129, 136, 145, 147, 149-152, 174, 177

## H

HABBAK, one of the mint family, 85  
 Habîr, Gebel, 163  
 Habûs, Wadi, 44, 45  
 Hadaiyid, Gebel, 66  
 Hadûd, Gebel, 15, 16, 25, 103, 146, 152, 198  
 Hæmatite, 166, 205, 206  
 Hagab, Gebel, 83, 85  
 Halafi, Gebel, 35  
*Halotis cruenta*, 103  
 Hallâl, Gebel, 52  
 —, Wadi, 52  
 Halliq, Wadi, 167, 168, 205, 206.—See also Khalliq, Wadi.  
 Hamad (or hamatha), *Rumex vesicarius*, 27, 52, 189, 213  
 Hamanier, Wadi, (or Maiat), 63  
 Hamâra, Wadi, 76  
 Hamât, Wadi, 43  
 Hamâta, Gebel, 75  
 —, Wadi, 64, 65  
 Hamedha, Gebel, 84  
 Hameier, Gebel, 163, 199  
 Hammad (or wild fig tree), 64, 75, 85  
 Hammâm Farûn, Gebel, (and Uset range), 29-31, 74, 107, 119, 125, 135, 150, 172, 173, 178, 198  
 — Saidna Musa, Gebel, 13, 14, 15, 18, 99, 109, 110, 131, 135, 155, 173, 179  
 Hamr, Gebel el, 66, 72  
 —, Wadi, 16, 17, 27, 28, 38, 45, 117, 147, 148, 155, 159, 161, 164, 173, 174, 175, 198  
 Hamra, Gebel, 47, 62, 188  
 Hanasia, Gebel, 89  
 Hanêk, Wadi, 52

Hares, 92

Harqûs, Wadi, 63, 180, 195, 197

Hash, Gebel Um, 186

—, Wadi Um, 87, 88, 97, 187

Hashia, Wadi Abu, 35

Hawa, Naqb el, path from Wadi Sahab towards, 64; 72-73, pass of, 76; 102, 180, 191

Hawara, Wadi, geology of, 108

Hazam, or wild mignonette, 85

Hebrân, Gebel, 190, geology of, 190; 191, 196

—, Wadi, 13, 14, 15, 21, 46, 46-50, 78-80, 82, 83, 87, 100, 183, 185, 190, 193, 202, 205, 213

Height of Debbet el Ramli plain 600 to 700 metres, 16; Gebel Abu Hoswa 692 metres, 20; Gebel Serbâl 200 metres, 21; Gebel Abu Alaqa 240 m., 24; Gebel Sarbut el Gemel 366 m., 27; granite hills over 600 m., 42; cataracts 100 m., 42; valleys with vertical sides 20 to 30 m. high, 53; mounds of limestone pebbles 30 m., 53; Gebel Serbâl 2,400 feet above Wadi Ferân, 54; Wadi 'Aleyat 700 feet, 55; ridge of Wadi 'Ajeleh 3,978 feet, 55; peak of El Madhawwa, 6,734 feet, 56; Gebel Serbâl precipice 4,000 feet, 57; rugged cliffs 600 or 800 feet, 59; ridge of gneiss 250 to 300 m., 61; Gebel Yena 600 to 700 m., 61; En el Akhdar 1,150 m., 63; ridge of gneiss about 200 m., 64; granite peaks 450 to 600 m., 65; Gebels el Hamr, Musa, and ed Deir 7,519, 7,363, and 6,739, 66; Gebel Moneijah 5,987 feet, 66; Gebels Ajramiyeh and Khizamiyeh 6,296 and 6,018 feet, 67; a precipice of Gebel Musa nearly 1,100 feet, &c., 67; Gebel Arremziyeh 2,000 feet, 67; a climb of about 1,500 feet to Ras Sufsafeh, 72; Er Rahah plain 2,000 feet, 72; Gebel Zebêr 8,551 feet, 73; Gebel Katharine 8,526 feet, 73; Gebel Abu Rumail 8,427 feet, 73; Gebel Koli 3,236 feet, 73; Gebel Um Shomer 8,449 feet, 73; granite mountains 1,000 to 2,500 feet, 75; Wadi Rimm el Mahasineh 5,075 feet, 77; Wadi Hebrân 1,002 m., 78; Gebel Moreia 2,050 m., 79; precipitous cliffs 150 to 200 m., 80; Gebel Wirqa 994 m., 80; Gebels Ramûz and Geba 800 and 933 m., 81; perpendicular walls of dark diorite 300 m., 82; Gebel Meqênus, 1,007 m., 82; Gebel Sawasia 6,480 feet or 1,975 m.; precipice of 1,280 m., 83; Fersh Abu Loz 1,064 m., 84, fall of 305 m. in, 85; grey granite cliffs 200 to 300 m., 86; a terrace over 900 m., 87; a watershed 915 m.,

97; Gebel Aal 460 m., 142; masses of limestone about 420 and 380 m. thick, 142; limestones 500 m. thick, 147; flinty limestone 400 m. thick, 151; sandstone 850 feet thick, 155; about 300 m. thick, 159; 144 m. thick, 163; Carboniferous and other beds about 350 m. thick, 163-164; throw of 900 m., 165; Carboniferous sandstone 450 m. thick, 168-169; 138 m. thick, 169; depth of Nubian sandstone nearly 300 m. below ground, 176; throw of 1,770, 1,320, 1,030, and 1,320 m., 176; Pleistocene sandstone 424 m., 187

*Heliastrea*, 123, 130

— ?, 122

— sp. nov. ?, 122

Helvetian period :—see Miocene, Middle.

Hemeir, Wadi, 180

Hemerat, Gebel, of red granite, 186

*Hemiasia Cenomanensis*, 131-133

— *cubicus*, 134-135, 135, 160

— *gracilis*, 133

— *Heberti*, 134, 135, 153, 154

— *scutiger*, 153, 154

Herbage; Herbs :—see Vegetation.

Hermits, (or pilgrims), 57, 71, 77

Heswa, El, a stream from Ferân oasis to, 60

Hesweh, Wadi el, palm grove in, 56, 59

*Heterodiadema libycum*, 133, 154

*Heterostegina*, a bed of, 112

— *depressa*, 112

Hiâla, Gebel, (and Abiad), plateau of, 32, 149

—, Wadi, 28, footpath from, to Wadi Ethâl, 33

*Hipponyx subru/us*, 103

*Hippurites*, 132, 149

*Holactypus Cenomanensis*, 135

— *excisus*, 133, 154

Holland, Rev. F. W., 70, 88, 95, 13 132, 183, 208, 211

Hornblende, 185, 195

— granite, 186

— schist, 201

Hoshera, Gebel, 32, 34, 35, 119-121, 208

Hoswa, Gebel Abu, 20, 190

Hot springs :—see Water.

Houses, 37, 39, 40, 44, 48, 50, 59, 62, 63.—See also Buildings.

Hull, 95, 123, 134, 155, 160, 162, 167, 169, 170, 171

Hume, Dr., 18

Hydrocarbons, 27, 147, 156, 198, 208-209

Hydrology of Western Sinai, 135

Hyenas, 92  
Hyrax, 92

# I

**IBEX**, 57, 61, 81, 92  
**Ibn Sakkar** :—*see* Sakkar.  
**Igneous rocks**, 14, 16, 19-21, 23, 38, 42, 46, 89, 93, 96, 97, 100, 109, 113, 127, 134, 139-141, 155, 156, 161, 163, 172-174, 179, 181-201, 211  
**Ikfa**, Wadi, 44  
**Iiban** (or Towara) trees, 82, 85. altitude-zone of, 91  
**Illimiana**, Gebel, 80, 83  
—, Wadi, 80  
**Ilti**, Gebel :—*see* Sawasia.  
—, Wadi, 82-84, 187, 193, 196  
**Indian Ocean**, fauna of, 181  
**Inliers**, 174  
**Inoceramus Crippesi**, 159  
**Inscriptions**, numerous, in Wadi Mokateb, 38, 39, an account of, in the "Ordnance Survey of the Peninsula of Sinai," Part I, 39; in Wadi Mokateb, 157  
—, Sinaitic, on rocks near Wadi Qarûra, 27; abundant in Wadis 'Alayet, 'Ajeleh, Nakhleh, and Th'mareh, 56; on Gebel Serbâl, and near the path to, 57-58, 58; in caves near El Madhawwa, 58; in Wadi Magheirat, 64; in Wadis el Leja and ed Deir, 71; in Wadi Rimm el Mahasineh, 77; in Wadi Kibrin, 79  
**Iron**, 157  
— mines, (maghara), in Wadi Khalliq, 43; old, in Wadi Halliq, 167  
— ores, 166, 167, 170, 205, and manganese, analysis of, 206, 206-207  
— oxide, 164, 169, sandstone free from, 205; brown ferric oxide, 206; ferric oxide, 208  
*See also* Ferruginous.  
**Isli**, Wadi, 86; Wadi Isla, 187  
**Isnan**, Gebel Um, 185  
**Isarca aquilina**, 135  
**Isocardia aequalis**, 132  
— *orientalis*, 132  
**Israelites**, the, 31; journeying of, 131  
**Iswed**, Gebel Um, 73, 83, 84, 185, 187

# J

**JORDAN VALLEY**, tectonics of, 183-184  
**Jubal Straits**, 182

# K

**KAHALI**, Gebel, 33  
—, Wadi, 36; geology of, 101  
**Kateb**, Wadi, 39  
**Katharina**, Gebel, 58, 59, 66, 70, 72-76, 83  
**Khadâhid**, Gebel, 23, 142  
—, Wadi, 23, 113, 122, 126, 130, 142  
**Khadéd el Dhib**, Gebel, 25, 107, 115, 121, 122, 177  
**Khalafa**, Gebel, geology of, 120  
**Khalaqa**, Wadi, 79  
**Khalliq**, Wadi, 43.—*See also* Halliq, Wadi.  
**Khamila**, Wadi, 45, 49, 180, 183  
**Khanasir**, Gebel, 186  
**Khashaba**, Wadi, 89, 90, 185  
**Khashm**, Wadi Um, 88  
**Khizamiyeh**, Gebel, 67  
**Khrêsa**, Wadi, 24, 114  
**Khrêta**, Wadi, 83-85, 187, 190, 193  
**Khurr**, Gebel, 79  
—, Wadi, 79  
**Kibrin**, Wadi, 79  
**Kidney ore**, 166  
**Kitâfa**, Wadi Abu, 36  
**Koli**, Gebel, 73, 83, 84, 187, 200  
**Krêr**, Gebel, 28, 29, 33, 119, 125, 128, 149  
**Krêt**, Wadi, 29  
**Kuplius**, (*Septaria*), cf. *arenarius*, 123

# L

**Laganum sinaiticum**, 99  
**Laha**, Wadi Um, 184  
**Lahiân**, Wadi, 44, 166  
**Lahm**, Gebel Um, 22, 188  
—, Wadi Um, 22  
**Lake**, a, formation of, 103  
— deposits, 100; fresh-water, 102-103  
**Lakes**, old, sites of, 103  
**Lampusia vilcaris**, 104  
**Lassaf trees**, 79, 80, 85  
**Lassaf**, Wadi Um, 79  
**Latch plants**, (natesh or), eaten by camels, 47  
**Lava**, 26, 134, 147, 160, 163, 178, 198-201, 204  
**Lavignon Baylei**, 132  
**Lebwa**, Wadi, 51, 52, 180, 188, 193-194  
**Legam**, Wadi, fossils from, 121, 134  
**Legends**, Arab, 27, 31, 53, 54, 67, 71, 72  
—, monastic, 71, 73  
**Leja**, Seil, 66, 67, 68, 69, 70, 76  
—, Wadi el, 66, 69-74

Leopards, 81, 92  
*Lepidodendron*, 160, 163, 164, 199  
 — Mosaicum, 161, 171  
 Letih, Gebel, 88  
 —, Wadi, 88  
 Levantine house, a, 37  
 Libyan :—see Eocene, Lower.  
 Lighthouses, the :—see Madhawwa, El.  
 Lightning, 48  
 Lilies, bluish white, and pink, beds of, 38 ; at  
 end of February, 64 ; purple, and white, 63  
*Lima*, cf. *squamosa*, 104  
 Lime, and traces of, 206  
 —, carbonate of, 98  
 — cement, 37, 116  
 Limestone, 13-16, 18-37, 41, 42, 46, 50, 53, 80,  
 90, 97-102, 107-117, 119, 120, 123, 124, 126,  
 127, 135-138, 140-152, 155, 159-161, 163-170,  
 178, 191, 198, 203-205, 208  
 —, Carboniferous, 42, 146, 148, 160, 162,  
 165-169, 168, 170, 178, 179, 198  
 —, chalky, 125, 140, 142, 151  
 —, coral-, 19, 108, 114  
 —, Cretaceous, 28, 117, 124, 131-154, 159,  
 168, 169, 173-179, 198, 208  
 —, crystalline, 28, 110-112, 114, 129, 138-140,  
 151, 158, 166-168, 202, 203, 216  
 —, dolomitised, 109 (and note)  
 —, Eocene, 110, 128, 134, 140, 149, 152, 177,  
 178  
 —, ferruginous, 136  
 —, flinty, 25, 30, 111, 112, 129, 136, 142,  
 144-146, 151  
 —, foraminiferal, 116, 124  
 —, knolls, 27  
 —, Lower Carboniferous, 162  
 —, Lower Eocene, (or Libyan), 128, 134 ;  
 Lower Libyan, 149  
 —, marly, 96, 102, 117-119, 136-138, 142  
 —, metamorphic, (and schist), 203-204 ;  
 comparative age of, 203  
 —, Middle Eocene, 128  
 —, Miocene, 110, 138, 145, 173  
 —, Nubian, 38  
 —, nummulitic, 110-118, 124, 127, 128, 134,  
 135, 137, 139, 150, 152  
 —, ochreous, 166  
 —, oyster, 136, 137  
 —, sandy, yellowish, 107, 114, false-bedded,  
 116 ; yellowish, 120, 137, white, 138  
 —, Senonian, 118, 151  
 —, Upper Cenomanian, 134

Limestone, Upper Cretaceous, (or Danian), 137,  
 151  
 —, Upper Cretaceous flinty, cliffs of, 147  
*Limopsis*, cf. *sordidus*, 104  
*Linthia*, basal fragment of, 130  
 — *oblonga*, 153, 154  
 Liquors brewed from dates, 15  
*Lithodomus*, sp. nov. ?, 107, 121  
 — (*Botula*), cf. *cinnamomeus*, 107, 121  
*Lithothamnium*, 122  
 Loam, 31, 34, 48, 49  
 Locusts, 81, 214  
 Loz, Ferish Abu, 84, 85, 187  
 —, Asqb Abu, 85, 86  
 Lucas, A., 206  
*Lucina*, 122  
 — *columbella*, 106, 121  
 — sp. div., 106, 121  
 — aff. *incrassata*, 106, 121  
 — *lingua-bovis*, 99  
 —, cf. *Safedensis*, 134  
 — aff. *tigrina*, 107, 122  
*Lymanæa*, immature, 102

## M

MACDONALD, Major, 39, 209  
 Mâdat el Melh, Wadi, 26  
 Madhawwa, El, (' the lighthouse '), 57, 58  
 Madsûs, Gebel, 28, 62, 79, 80, 83, 84, 89, 148,  
 185, 187, 195, 200, 202  
 Maghara, Gebel, 14, 16, 37, 39-41, 157, 161,  
 179, 185, 198, 199, 209  
 Magheirat, Wadi, 64, 191, 193  
 Magrifat, Wadi, 76  
 Maharrad, Wadi el, 59  
 Maiat, Wadi, (Hamanier or), 63  
 Main, Wadi, water in, 61, 84  
 Maize, Bedawin gardens of, 59  
 Malachite ore, 166  
 Malagan, Wadi, 179  
 Malaqa, Gebel Um, 89, 185, 186  
 —, Wadi Um, 89, 97, 186, 192  
 Malha, Wadi, 163-166, 205, 206  
 Mammal, a, tooth of, 102  
*Mammilla*, (*Natica* vel.), *melanostoma*, 104  
 Manganese, 118, 148, 207, 208  
 Manganese mines (maghara), in Wadi Khalliq,  
 43 ; old, in Wadi Halliq, 167, 205  
 — ores, 166, 167, 169, 170, 205-208  
 Map, Ordnance Survey, 62, 123

Maps, geological :—see Geological maps.

Maqad el Nebi Musa, 65

Maraikh, Wadi, 48

Mareiah, Gebel, 62, 185, 196, 196, 200, 202

*Maretia Fuchsi*, (*Spatangus ocellatus* =), 119

*Margaritifera vulgaris*, 105

Marit, Gebel, of red granite, 186

Markh, Gebel Abu, 89, 186

Markh trees, 89

Markh, Wadi Abu, 88, markh trees in, 89

Markhâ, El, 15, 16, 25, 41, 101, 117, 135, 146, 155, 157, 168, 172, 174, 178, 198

Markhâ, En el, 146

—, Gebel el, 15, 16, 24, 38, 164, 168, 178

Markhîa, El, a gravelly beach, 25

Marl, 18, 23-26, 29, 36, 37, 41, 42, 87, 90, 92, 100, 102, 103, 108, 113-120, 134-137, 143, 144, 148-152, 159, 160, 170, 174, 177

—, Cenomanian, 134, 135

—, Cretaceous, 23, 28, 41, 96, 109, 115, 117, 124-127, 129, 139, 140, 145, 146, 148, 149, 151, 152, 154-157, 159, 175, 177, 178, 198

— escarpments, 22, 137, 143

—, gypseous, 32, 34, 35, 101, 108, 115, 116, 119, 129, 136, 145, 151, 152

— hills, (foothills), 23, 30, 145

—, Miocene, 145

—, ochreous, beds of, 167, 168

— plateaux, 23, 25, 37

— Upper Eocene, (or Bartonian), 176

Marly clay, greenish, 32, green, 118

— crystalline limestone, 140, 158

— Eocene limestone, 140

— limestone, 96, 102, 117-119, 136-138, 142

— sandstone, greenish, 118; mottled, 118

Marshes, 15, a salt, 28; 99, 102-103

Marzeqa, Gebel, 50

—, Wadi, 84

Mas el Dhabba :—see Dhabba.

Masraia, Gebel, a mass of red granite, 89, 186

Matab el Dêr, 75

Matakh el Barûd, Gebel, 79, 185, 190, 202, 203

Ma'yan Musa, 71

Meâr, Wadi, 13, 14, 79, 82, 83-84, 84, 85, geology of, 99, 184, 187, 190, 192, 193, 195, 205

Mediterranean characters of fossils, 106, 107; shells, 180; fauna, 181

— Sea, 181

*Melania* shells, 101

Melaphyre-basalt, dark, 118

Melbe, Wadi, a well in, 34

Melha, Wadi, a well of brackish water in, 45

*Melongena paradisiaca*, 104

"Mémor on the Red Sea Hills," 216

Meqênus, Gebel, 82, 83

—, Wadi, 82

Merâq, Wadi, 44

*Meretrix*, 130

Meringa, Wadi, fossils from near, 166, 171

Merzeqa, Gebel, 39, 49

Metamorphic rocks, 42, 46-48, 50, 134, 139, 152, 161, 169, 182-204

*Metastrea Egyptorum*, 105

Meteorology, 90-91

Mezeraq, Gebel Abu, 84, 200

Mica, 51, 194, 202

— -schist, 59, 202

Micaceous diorite bed, 195

— gneiss, 195

— granite, grey, 191, 193

— rocks, altered, 201

Micro-granite dykes, 193, 196

Mignonette, wild, (hazam or), 85

*Miliolina circularis*, 128

Minas, Brazil, the manganese deposits of, 207, analyses of, 207-208

Miners, turquoise, ruined houses of, and of their guards, 40, 210; tools used by, 211

Mines, old mining centres, 131

—, copper, workings, in Wadi Nasb, 44; old, in Wadi Malha, 166; old, in Wadi Halliq, 167, 206

—, iron, (maghara), in Wadi Khalliq, 43; old, in Wadi Halliq, 167

—, manganese, (maghara), in Wadi Khalliq, 43; old, in Wadi Halliq, 167, 206

—, turquoise, in Gebel Maghara, 37, 39, worked by Major Macdonald, 39; names and descriptions of, 40; ancient Egyptian workings, 40; workings in Wadi Serabit el Khâdim, 45; beds, disappearance of, near Maghara, 157; in Wadi Qena, 164; in Wadi Qenaia, 165; ancient Egyptian workings, 169; beds in Gebel Maghara, 199, 209; beds in Serabit el Khâdim, 209; in Wadis Qenaia, Qena, and Sidri, with their distinctive names, 210; the richest, 211; Bauerman on, 211; 211-212

Mint, 80, 85

Miocene beds, 95, 98, 106-123, 125-127, 134, 135, 137, 138, 140, 141, 143-147, 151, 152, 173, 177, 178, 180, 181, 200

*Mitra aureolata*, 104

Models, 65, 69

Mohammed, Ras, 13, 14, 15, 46, 74, 88, 90, 92, 97, 105, 172, 174, 182, 183  
Moina trees, resembling mountain-ash, 82 ; altitude-zone of, 91  
Mokateb, Gebel, 23 ; and Gebel Withr, plateau between, 24 ; 38, 89, 114, 126, fossils from, 132-133 ; 143, 173, 186  
—, Wadi, 14, 16, 38, 39, 49, 50, 88, 132, 133, 155-157, 177  
Moket el Dhib, Wadi, 89  
Monastic buildings, 70, 71, 73, 75-78.—*See also* Convent.  
Moneijah, Gebel el, 59, 66, 69, 72  
Monia, Wadi, 47 ; 62  
Monks of the Greek Church, 15, 18, 70, 71, 78  
Moreia, Gebel, 62, 75, 76, 79, 80, 83, 190, 191, 213  
—, Wadi, 79  
Morêta, Wadi, 79  
Morit, Wadi, 88  
Morr, Gebel, 24, 151  
—, Wadi, 24  
Moses, 65, 67, 71-74  
Mosque, a, nearly in ruins, 67  
Мозек, 59, a profusion of, 75  
Motalla, Gebel, 186  
Mount of the Law, the true Sinai, Gebel Musa, 67.—*See also* Musa, Gebel.  
Movements, earth, 18, 90, 111, 113, 210  
Mud, salty, 28, 85  
*Murchisonia*, 161  
*Murex ternispina*, 104  
Murr, Wadi, 84, 85  
Musa, Gebel, 14, 17, 26-28, 48, 62-74, 90, 180, 213  
—, Ma'yan, (= the spring of Moses), on Gebel Musa, 71  
—, Saidna :—*see* Hammam.  
—, Shagg, a dark, rocky glen, 74  
—, Sikket Syedna, 71, 72  
Muschelkalk limestone, 155  
Museum, Natural History, London, 98, 103, 107, 120, 124  
Musical sand, near Gebel Naqus, 19

## N

NAKHL, Wadi, road from Wadi Sadr to, 36  
Nakhleh, Wadi, 56  
Naqa Gamila, plateau of, 36  
—, Wadi, 36  
Naqb Abu Loz ; Budra, &c. :—*see* Loz ; Budra, &c.

Naqus, Gebel, 33, 43, 44, 159, 162, 164, 166-169, 171, 178, 179, 182, 205, 208  
*Nassa (Alectron) glans*, 104  
— *pulla*, 104  
Natash plants, (or latsh), eaten by camels, 47  
*Natica*, 122  
— (*Mammilla*) *melanostoma*, 104  
— *redempta*, 107, 121  
Natural History notes, 91-93  
Neba, Wadi, 50  
Nebk, the fruit of the sidr tree, 59  
Necks, dolerite, 79, 83, 84, 187, 187-188, 193, comparative age of, 204  
—, volcanic, 200, 200-201  
*Neithia alpina*, 131  
— *tricostata*, 131  
Neocomian period, 160  
*Neptunus granulatus*, 118  
*Nerinea*, 138, 148  
—, large, 158  
— *olisiponensis*, 153  
*Nerita Albicilla* (= *crassulabrum*), 103  
Neumayr, 180  
Newton, R. B., Natural History Museum, London, fossils determined by, 103-106, 107, 120-123, 130, Cretaceous fossils determined by, 153-154 ; Carboniferous fossils determined by, 171  
Nidia, Wadi, 50, 51  
Nile valley, 91, 100  
Nilma, Wadi, 44  
Niqwat el Amri, Wadi, 76  
Nisisât, Gebel, 15, 25, 144  
—, Wadi, 25  
Nisrin, Ferah, 49, 50, 51, 194  
—, Wadi, 23, 48, 50, 51, 189, 194, 197  
Nodules, large, of pure manganese ore, 205 ; phosphatic, resembling coprolites, and analysis of, 208.—*See also* Pebbles.  
Nokkel, Gebel, 25, 26  
—, Wadi, 25, 27, 146, 198  
Nubia, Russeger's geological map of, 154  
Nubian limestone, 38  
— sandstone :—*see* Sandstone.  
*Nucleolites similis*, 133  
*Nullipores*, 119  
Nummulites, 108, 110-116, 118, 124, 125, 127, 128, 134, 135, 137-139, 141, 143-145, 150, 152, 177  
*Nummulites*, 124, 126  
— *Barroni*, (sp. nov.), 128  
— *curvispira*, 128, 130

*Nummulites Gizehensis*, 113, 116, 125, 126, 130, 137, 140, 142  
 — —, var. *Ehrenbergi*, 127  
 — —, var. *Lyelli*, 127  
 — —, var. *Pachoi*, 126, 127  
 — *Guccardi*, var. *antiqua*, 128  
 — *planulata*, 124  
 — *Ramondi*, 129  
 — —, ? 126  
 —, rolled, 115, 118  
 —, small, 125  
 — *subdiscorbina*, 126  
 — *variolaria*, 124  
 —, cf. *variolaria*, 118

○

OASIS, 51, 56, 63.—See also Ferân, oasis of.

Ochre, red, (or raddle), 208

Ochreous grit, 115

— limestone, 166

— — beds, layers, 163

— marl beds, 167, 168

— nodules, 211

— sand, 210

*Odontaspis macrotus*, 130

Oligocene deposits, and absence of, 181, 204

*Oliva inflata*, 104, 105

Olivine-basalt beds, (cap), 163

*Operculina*, 124

— *complanata*, 122, 123, 129

—, var. *canaliculata*, 128

— —, var. *discoidea*, 124

*Orbicella*, 122

— *Forskaliana*, (= *mammillosa*), 105, 106

— *Schweinfurthi*, 122, 123

*Orbitoides spansa*, 124, 126, 128

— *ephippium*, 126

— *papyracea*, 126, 128

Ordinance Survey map, 62; geological, 123

Ordinance Survey, the, 19, 24, 30, 39, 40, 45, 52, 54-60, 65-74, 83, 92, 131-133, 161, 183, 184

Ores, copper, in Wadi Nasb, 44; in Wadi Malha, 166; in Wadi Halliq, 167, 206; in Wadi Nasb, 208; in slag on Gebel Safariat, 208

—, iron, 166, 167, 170, 205, and manganese, analyses of, 206, 206-207

—, kidney, 166

—, malachite, 166

—, manganese, 166, 167, in the form of wad,

167; 167, 170, 205, earthy, on wad, 205; nodules of pure, 205; and iron, analyses of, 206, 206-207, 207-208; from Minas, Brazil, 207, analyses of, 207-208; 208

See also Gangue.

*Orthis Michelinii*, 161

Orthoclase, feldspars resembling, 196

— feldspar, pink, 189

*Orthotetes Crenistria* ?, 171

Oshad shrubs, 82

Osiers, (willows or), 67

*Ostrea*, 99, 107, 118, 119, 121, 122, 125, 130, 140, 148, 153

— *africana* (= *Auressensis*), 135, 153, 154

— *alicula* ?, 153

— *Auressensis*, 131, 132

— —, var. *major*, 131

— *batillum*, 119

— *Boblayei*, 108

— *Clot-Beyi*, 127, 130

— *costata*, 133

— of the *Crassissima-gingensis* group, 107

— *cucullata*, 107

— *curvirostris*, 131, 133

— *Dellatrei*, 133

— *dentata* (= *Auressensis*), 133

— *digitalina*, 121

— —, var. *Rohlsi*, 119, 121, 122, 123

— *flabellata*, 153, 154

— *flabelliformis*, 133

— *Forgemolli*, 133

— *Fraasi* (= *elegans*, var. *exogyroides*), 127, 130

— *frondosa*, var. *candata*, 122

—, large, 116, 138

— *Mermeti*, 133, 134, 135

— *olisiponensis*, 153, 154

— *plicata* (= *Overwigi et Boussingaulti*), 133

— *ravilamella*, 127, 130

— *rediviva*, 154

— *Reili*, 130

—, small, 136

—, strongly beaked, 111

— *suborbiculata* (= *Mermeti*), 153, 154

— *syphax*, 133

—, thick, 138

—, thick-shelled, 112, 117

—, cf. *undata*, a Mediterranean form, 107, 121

—, upper valve indet., 105

—, various sp., 142

— *vesicularis*, 133, 134

— *Vireti*, a bed of, 109, 111, 112, 114, 118,

123.—See also Oysters.

Ogha, Wadi, 84  
 Overlap, 129, 165, 169, 170  
 Oxide, iron-, 164, 169; brown ferric oxide, 206;  
     ferric oxide, 206  
 Oyster-limestone, 136, 137  
 Oysters, bank of, 36, 101, 113, 114, large, 116;  
     119, 120, 126, 127, bed of, 136; large, 138.—  
*See also Ostrea.*

## P

PALACE, the, of Abbas Pasha, ruins of, 14, 83  
 Palaeozoic, Early, period, 203  
 Palestine, Western, Memoir on, by Hull, 123  
 Palm trees, 15, 16, 19, 22, 26, 28, 29, 31, 32,  
     36-38, 42-44, 55-60, 63, 71, 75-78, 80, 82,  
     83, 85, 87, 102, 103  
 Palmer, Captain H. S., R.E., 54-60  
 Palmer, Mr., 57  
*Papillicardium papillosum*, 123  
 Parallel faults, three, 137-138; two, 145  
     — hills, 65  
     — mountain ranges, 19, 110  
     — ridges, limestone plateaux and, 18-33;  
         20, 65, due to weathering, 90; marl, 137  
     — valleys, two lateral, 49, 52, 65; lateral, 89  
 Paran, Wadi, 55, 59  
 Parisian deposits :—see Eocene, Middle.  
 Partridge, 81, 92  
 Passes, 34, 44, 60, 75, 76, 78-81, 83, 85, 87  
 Peaks, 18, 22, 33, 42, 49, 50, 54, 62, 65, 67, 69,  
     71, 73, 75, 79, 83, 86, 88, 186, 187, 189, 190,  
     213, 214  
     —, diorite, 89  
     —, dolerite, 89  
     — granite, 65, cluster of, 66; 77, red, 185,  
         188; pink, 190  
     —, quartz-felsite, 89  
     —, syenitic granite, 74  
 Pebbles, 14, 17, 34, 53, 100, 108-117, 119, 124,  
     128, 129, 149, 156-158, 162, 211  
*Pecten*, 101, 107, 109, 111-121, 125, 129  
     — *alpinus*, 133  
     — *asper*, 131, 133  
     — *Barroni*, (sp. nov.), 106, 120  
     — *benedictus*, 107  
     —, cf. *Beudanti*, (not *Zisiniæ*), 122  
     —, coarsely ribbed, 108  
     — *cristalocostatus*, 121  
     —, var. *Newtoni*, 118, 122  
     — *cristatocristatus*, 118

*Pecten cristatus*, 106, 120, 121  
     — *gloria-maris*, var. *longolavis*, 122  
     — *Joslingi*?, 107, 121  
     — *Kochi*, (= *Fraasi*), 107, 121, 122  
     —, large, 112, 138  
     — *Malvinæ*, 119  
     — *Marrotianus*, 133  
     — *obtus*, 133  
     —, cf. *opercularis*, 106, 120, 123  
     — *revolutus*, 106, 120, 121, 122  
     — *scabrellus*, (= *Sarmenticus*), 106, 120  
     —, —, 1, 107, 121  
     — *Schweinfurthi*, 106, 120  
     — *sub-Malvinæ*, 107, 121, 122  
     — *tricostatus*, 133  
     — *varius*, 107  
     —, cf. *Zitteli*, 122  
     — *Zisiniæ*, 121, 122  
*Pectunculus*, 122  
 Pegmatite, veins of, 196  
*Pelecypoda*, 98, 115, 125, 168  
*Periaster elatus*, 133  
     — *oblongus*, 131, 132, 133  
 Permian period, 168  
 Petroleum, smell of, from hot springs, 30  
 Pharaoh the accursed, bath and legend of, 31  
*Pholadidæ*, borings of, 114  
 Phosphatic nodules, 208  
 Photographs, 65, 215  
*Physa*, small, 102  
*Physostoma Delamarrei*, 131, 133  
 Pilgrims, (hermits or), 57, 71, path for, 72  
*Pirenella mammillata*, 104  
 Plains, 15-18, 21, 24, 27, 31, 33-39, 42, 43, 46-  
     49, 52-54, 61, 68, 69, 75, 80, 81, 86, 87, 89,  
     90, 92, 97, 98, 99, 101, 102, 111, 113, 150,  
     151, 156, 158, 159, 164, 167, 172, 179, 186-188,  
     212, 216.—*See also* Plateaux.  
 Plants, 33, 52, 59, 61, 64, 80, 81, 84, 85, 86, 91,  
     92, 102, 163, 213-216.—*See also* Vegetation.  
 Plateaux, 17, 21-25, 27, 28, 32-38, 41, 43, 44,  
     47, 48, 50, 52-54, 61, 63, 64, 73, 77, 80, 83,  
     84, 92, 101, 108, 115, 116, 127, 141, 146, 148,  
     159, 166, 172, 175, 180, 184, 187, 188, 194,  
     195, 197, 198, 199, 214  
     — beach-, between Gharandel and Suez, 33-  
         37, 38  
     —, Cretaceous marl, 23  
     —, granite, pink, 62; plateau-like mass, 80;  
         red, 89; red, 188; grey, 188, 189, 194, 195  
     —, gravel, 15  
     —, gypsum, 15, 24, 25

Plateaux, limestone, 15, and parallel ridges, 18-33; 23, pinkish white, 24. 25, 35-36, 36, 37, 53, 80, due to fracture, 90; 100, 112, 114, 167, 167-168, 208  
 —, marl, 23, 25, 37  
 —, metamorphic, 47  
 —, Miocene, 115  
 —, Pliocene, 101  
 —, salt-bearing clay of, dark green or brown, 101; greenish, 102  
 —, sandstone, 27, 37-46, 41, 45, 47, 49  
 —, sandy clay, of, 101  
 —, sedimentary, 21  
*See also* Plains.  
 Pleistocene, Recent and, beds, 96-108, 182, 187, 215  
*Plicatula* aff. *batensis*, 154  
 — *Fourneli*, 131, 132  
 — *polymorpha*, 130  
 — *ramosa*, 104  
 — *reynesi*, 135, 153  
 Pliocene beds, 101, 106-108, 111, 180, 181, 182  
*Porites*, cf. *incrustans*, 105, 106  
 Porphyritic dolerite dykes, 189  
 — felspar, 185, 186, 195  
 —, glomero-, beds, patches, 189, 197  
 — granite, pink, 185, 185-186, 188, 189-192; 190, pink, 190; grey, 192; pink, 203, comparative age of, 203; 204  
 — — bosses, 192; knob, 192  
 — — hills, (foothills), 190; ridge of, 192  
 — — rocks, pink, characters of, 189-190, free from blemishes, 190; 191  
 — quartz-felsite bosses, 197  
 — quartz-felsite cliff, 63  
 — quartz-felsite dykes, 195, 197  
 — rocks, 182  
 Porphyry, 184, 211  
 Post, camel-, the weekly, between El Tor and Suez, 14; camel-track used by post-runner, 24  
*Poteriocrinus*, 161  
 Precipices, 16, 21, 24, 28, 30, 40, 42, 51-54, 57, 61, 65, 67, 69, 71, 77, 79-81, 83, 84, 112, 113  
*Prionastraea*, 105, 106  
*Productus*, 166, 167  
 — *scabriculus*, 171  
*Protocardium Hillanum*, 133  
*Psammechinus dubius*, 119  
*Pseudodiadema*, 149  
 — *Ruppelli*, 133  
 — *variolare*, 132, 133  
 Psilomelane, 166, 206

Pyramids, Giza, shells from Zlypeaster sands near, 180  
 Pyrolusite, 166

## Q

Qâ, El, plain of, 13-15, 18-23, 80, 90, 92, 96-100, 102, 109-112, 114, 134, 135, 139, 140, 143, 144, 155, 172, 177, 179, 182, 185, 190, 213  
 Qaban, Wadi, 76  
 Qabeliat, Gebel, 18-20, 110, 112, 114, 122, 127, 137-139, 148, 151, 153, 177  
 —, Wadi, 20, 21, 111, 128, 137, 138, 153  
 Qâda, Wadi Abu, 28, 32, 33, 124, 130, 149, 159, 174, 176, 178, 179, 198  
 Qallam, Wadi Abu, 23  
 Qarâra, Wadi, 27-28  
 Qasr`Abbas Pasha, Gebel, 14, 76, 83, 185, 187, 188, 200  
 Qassab, Wadi, 65, 74, 102  
 Qân, Wadi, 84  
 Qena, Wadi, 39, 40, 164, 165, 199, 210  
 Qenaia, Wadi, 39, 40, 165, 210  
 Qersin Utud, Gebel, 87  
 Qirit el Maghaddi, Wadi, 76  
 Qosêr, Wadi, 53  
 Qrum, 15, 98, 99, 103-105  
 Quarantine buildings, at Qrum, 15; at Ayun Musa, 37; at Qrum, 98  
 — regulations, 37  
 Quartz, 17, 48, 51, 89, 99, 158, 166, 185, 187, 189, 194, 197, 202  
 — -diorite, 192, 195  
 — -felsite, 60; veins of, 186, 187, 188, 195, 196, 197  
 — —, diorite-, 186  
 — — dykes, 82, 186, 186, 187, 190, 192, 193, 194, 195, 196, 196, 197, 204  
 — —, glassy, 196  
 — —, gneissose, dykes of, 197  
 — —, porphyritic, 63, 195, 197  
 — -schiefer rocks, (schistose felsite), 201  
 Quartzite, 156-158, 162, 163, 186, 199

## R

RABOISSON, M., 108, 183, 184, 198  
 Raddle, (or red ochre), 206  
*Radiolites*, 131, 137, 140  
 Raha, Gebel el, 35, 36, 101, 125  
 —, Wadi el, 180

Rahaba, Wadi, 52, 53, 61, 188, 193, 197, 202  
 Rahah, Er, 66-69, 72  
 Rahu, Wadi, 84  
 Rain, 18, 32, 38, 42, 48, 53, 60, 88, 91, 136, 205, 213, 214, 215  
 Raised beaches, 15, 20, 36, 98, 102, 109, 182  
 Ramli, El, plain of, 45, 47, 48  
 Ramûz, Fersh el, 80, 191  
 —, Gebel, 80, 81, 190, 196  
 —, Wadi, 80-81  
 Raqqa, Wadi, 21, 22, 140, 153, 174  
 Ras Ethâl, &c. :—see Ethâl, &c.  
 Rashid, Gebel, 186  
 —, Wadi, 88, 89, 97, 186  
 Ravens, 92  
 Ravines, 29, 55, 57, 66, 69-72, 74, 77, 78, 81, 84  
 Recent area, and Pleistocene, 96-106  
 — beaches, 99, 101, 109  
 Red Sea, the two arms of, 74; shells living in, 99; age of rift of, 180; shells from, 180; origin of arm of, 180-181; Gulf of Suez older than, 181; invasion by, 181-182; the fault causing, 182; waters of, 182; Gulf of Suez geologically older than, 182; 185  
 — — hills, 181, Memoir on, 216  
 Reeds, 31, 60, 75, 80  
 Reefs, 110, 180  
 —, coral, 89, 99, 134, 155  
 Rên, Wadi Um, 33  
 Reshahab, Sikket er, 57  
 Retem bushes, 27, 29, 32, 52, 55, 61, 62, 63, 64, 76, 84, 85, 91  
 — trees, 38, 62  
 Retema, Gebel, a granite boss, 62, 188  
 —, Wadi Um, 32, 52, 61, 62, 191-192, 193  
*Reticularia lineata*, 171  
 Rowas, Wadi Um, 87  
*Riodocrinus*, 161  
*Ricinula ricinus*, 104  
 Rieh, Gebel Um, 87, 187  
 —, Wadi Um, 87  
 Rift valleys, and origin of, 180; 188  
 Rifts, 172, line of, 174; lines of, 180; in the Eastern Peninsula, 180; of the Gulf of Suez, age of, 180-182; of the Red Sea, age of, 180  
 Riglên, Gebel Um, 45, 166  
 Rigma, Gebel el, 23, 112, 113, 122, 126, 130, 142, 172  
 Rim, Wadi el, 77  
 Rimm el Mahasineh, Wadi, 57, 77  
 —, Wadi er, 55-57, 77, 78  
 Rimth Plants, 36, 39, 41, 50, 64, 86

Rio, railway to, 207  
 Roads : for camels, from El Tor to Suez, 14; for carriages, (Sikket Abbas Pasha), from El Wadi to Wadi Hebrân, 14; from El Tor to Gebel Musa, 14; good camel-tracks across the plain of Sêh Sidri and El Markhâ, 16; northern road from Suez to Gebel Musa Convent and Wadi el Dêr, 17; camel-path in Wadi Abu Suwêra, 19; from El Qâ to Wadi el Araba, 19; on sea-coast, 20; through pass near Gebel Naqus; path from Wadi Abûra, across Serbâl; path from Wadi Abûra, across Serbâl to Ferân, 22; footpath from Wadi Thaghadi to Serbâl, 23; camel-track used by post-runner between Suez and El Tor, 24; from El Markhâ plain to Wadi Tayiba, 25; excellent, in Wadi Tayiba, branching to Gebel Musa, &c., 26; to Suez, in Wadi Shebêka, 26; in Wadi Hamr, 27; branching, in Wadi Qarûra, 27-28; bad, from Wadi Hamr, 28; over flank of Gebel Abu Dêmat, 28; Suez road near Ethâl, 28; between Wadis Ethâl and Usêt; difficult for camels, 29; difficult, in Wadi Gharandel, 31; Suez road in Wadi Gharandel, 31, 32; very bad, from Wadi Um Silfa to Wadi Baqa, 33; from Wadi Silfa to En Hawâra, 34; path (Sikkat Amâra) from Wadi Silfa to Wadi Amâra, 34; from Wadi Sadr to Nakhl, 36; of narrow parallel tracks from Wadi Dehêsa to Ayun Musa, 36; carriage-, remains of Abbas Pasha's, from Ayun Musa to the sea, 37; difficult, in Wadi Mokatab, 38; winding in Wadi Sidri 40; difficult path in Wadi Budra; to Wadi Baba, Sêh Baba, and El Markhâ, 41; camel-path from Wadi Shellâl to Naqb Budra, 41-42; paths from Wadi Nasb towards Serabit el Khâdim, &c., 44; difficult path from Wadi Serabit el Khâdim to Wadi Khamila, 45; difficult path from Wadi Siq and Gebel Dhalâl to Wadi el Akhdar, 45; a path from Wadi Um Bassal to Wadi Entish, 47; path from Serabit el Khâdim to Gebel Musa, 48; very rough and stony, in Wadi Barraq (or Barq), 48; in Wadi Nidia, 50-51; rugged pass from Wadi Rahaba, 52; rude footpath from Wadi 'Ajeleh towards Tor, 56; in Tarfa grove, 60; from Suez to the Dêr at Gebel Musa; several, meet in Wadi Solêf; Gebel Musa road in, 62; camel-track from Wadi Harqus to Wadi el Sheikh and El

Watia ; northern route from Wadi Hamanier to Fersh Elwi el Agramia and Gebel Musa, 63 ; central, from Suez to El Dâr, 64 ; path from Soleb to Wadi Qassab, 65 ; from El Watia pass to Aqaba ; and Ras Safsafa, 65 ; five paths up Gebel Musa, 71 ; path from Wadi el Gharbi to Naqb Hawa, 75 ; 78 ; a path from Wadi Ât el Gharbi to Wadi Khashaba, 89

*Rotalia calculiformis*, 126

Rothpletz, 95, 108, 119, 151, 168, 171

Rubble beds, 149, 167, 206, 212

Ruins, 18, 22, 39, 40, 44, 48, 57, 59, 63, 70-72, 75-79, 83

Rumail, Gebel Abu, 73, 83, 84

*Rumex vesicarius*, hamad, or hamatha, patches of, eaten by camels and by the Bedawin, 27, 52 ; hamada, 89, 213

Rummâna, Wadi el, 51, 53, 188, 189, 193, 197, 202

Rushes, 37, 59, 75, 81,

Russeger, 95, 154, 155, 161, 182

Russia, consular agency for, at El Tor, 15

## S

Sâ, Gebel Um, a plateau-like mass, 187

Sadr, Gebel, (or Gebel Taset Sadr), 35

—, Wadi, 35, 36

Sadur, Sikket, 57

Safaria, Gebel, 172

Safariat, Gebel, 21, 127, 128, 130, 139, 140, 153, 174, 177, 208

Safsâfa, Ras, 65, 66.—*See also* Sufsafah.

Saha, Gebel Um, 83, 84

Sahab, Wadi, 64, 180

Sahara, Gebel, 89, 186

—, Wadi, 89

-Said, Port, 205

Saidna Musa :—*see* Hammam.

Sakkar, Wadi Ibn, 27, 48, 117

Sakran plants, 27, 35, 36

*Salenia Batnensis*, 153

Salt, 14, 15, 28, 98-102, 107

Samr el Tinia, (or et Tiniyer), Gebel :—*see* Qasr Abbas Pasha.

Samra, Gebel, 15, gneiss range of, 175

—, Wadi, 42

Sanafa, Gebel, a limestone hill, 33, 125, 178

Sand, 13-17, 20, 21, 24, 25, 27, 28, 30-32, 34, 36, 39, 41, 43-47, 49, 50, 52, 53, 60-63, 75, 80, 82, 86, 87, 96-102, 107, 109, 112, 114-116,

120, 137, 133, 146, 156-158, 167, 186, 196, 199, 212, 216

Sand, calcareous, 119

—-clay, 14, 35, 96-99, 101-103, 136

—-dunes, 21, 90

—, ferruginous, 149

—, granite, 49, 62, 98

—, grey, 136

—, loamy, 48

—-marl, 136

—, musical, 19

—, ochreous, 210

—, Oligocene, 181

—, salty, 98-100

—-shale, 41, 149

—-shell, 36

—-terraces, 61

—-valleys, 34, 83

—, white, 111

—, yellow, 208

Sandstone, 17, 19, 21, 22, 27, 28, 35, 38-41, 43-50, 89, 90, 97, 99, 108, 113, 114, 116, 149, 154-170, 175, 178, 182, 183, 186, 187, 196, 199, 202-204, 211, 216

—, black, 118, 156, 209

—, brown, 46, 156, 161

—, calcareous, 101, 108, 109, 112, 118, 119, 136, 149

—, Carboniferous, 42, 44, 155, 158, 165, 166-170, 175, 177, 185, 192-194, 198, 199, 201, 203, 210

—, Cenomanian, 160

—-clay, 158

—, Cretaceous, 160, 161, 199

—, Devonian, 170

—, Egyptian, 155

—, ferruginous, 165

—, green, 116

—, grey, 118

—, Lower Carboniferous, 169, 170

—, Lower Cretaceous, 161

—, marly, 118

—, metamorphic, 203

—, Neocomian, 160

—, Nubian, 17, 18, 27, 37-49, 90, 109, 114, 115, 124, 127, 135-138, 145, 146, 148, 150, 154-161, 163-165, 170, 175, 176, 178, 179, 183, 184, 209, 216

—, Pleistocene, 187

—, Post-Carboniferous, 162

—, purple, 156

—, red, 16, 19, 22, 24, 39, 41, 42, 46, 156, 161

Sand, Upper-Carboniferous, 155, 165, 169, 170  
 —, white, 45, 46, 156, 158, 162, 163, 205; 209  
 —, yellow, 100, 109, 155  
 Sarbāt el Gemel, Gebel, 26, 27, 28, 38, 108, 117;  
 121, 147, 148, 159, 175  
 Satakh, Wadi el, (Ghadir or), 61, 193  
 Sawasia, Gebel, 83, 84, 185, 187, 196, 200  
 —, Wadi :—see Ilti.  
*Scaphander*, 130  
 Schiefer, granat-, 203  
 —, quartz-, rocks of, (schistose felsite), 201  
 Schist, 170, 191, 201-203  
 — felsite rocks, (quartz-schiefer), 201  
 —, hornblende-, 201  
 —, metamorphic, limestone and, 203-204  
 —, mica-, 202  
 —, —, cliffs of, 59  
*Schizaster*, 120  
 —, of *Parkinsoni*, 120  
 Schweinfurth, Dr., 91, 142  
*Sciella*, 109, 111, 113  
*Scutum unguis*, 103  
 Seba'iyah, Wadi, 66, 67, 69  
 Sections :—see Geological.  
 Sedimentary rocks, 18-46, 50, 93, 109, 113, 125,  
 127, 134, 139, 140, 155, 156, 172, 173, 175,  
 176, 181, 182, 185, 186, 198, 202  
 Sedimentation, 161  
 Sêh Sidri :—see Sidri.  
 Seileh, Wadi Abu, 68, a stream in, 70  
 Seils; Sêls :—see Torrents.  
 Senonian beds, 118, 129, 134, 151, 170  
*Septaria*, (*Kuphus* vel), *arenaria*, 123  
*Septifer bilocularis*, 104  
 — *excisus*, 104  
 Serabit el Khâdim, Gebel, 45, 49, 163, 169  
 — —, plateau of, 45, 199  
 — —, Wadi, 45, 48, 49, 162, 166, 169, 185,  
 209  
 Seraibil es Sugheireh, Gebel, 56  
 Serbâl, Gebel, 18, 21-23, 48, 51, 54-59, 62, 74,  
 77, 80, 81, 83, 90, 172, 176, 188, 190, 202-204,  
 213  
*Serpula spirulæa*, (derived from Eocene), 121  
 Seyal trees, 16, 22, 28, 38, 39, 41, 44, 48, 49, 50,  
 51, 53, 59, 64, 76, 79, 80, 82, 84-86, 89, 91, 102  
 Shadufa, 44, 59, 63, 82  
 Shale, 41, 129, 131, 135, 136, 149, 161, 169, 191,  
 203  
 Shâr, Abu, 181  
 Sharks' teeth, 120; teeth of fish, 126, 140  
 Shebâka, Wadi, 26-27

Sheep of the Bedawin, 17, 53, 85, 87, 215.—*See*  
*also* Flocks.  
 Sheikh Ahmed :—see Ahmed.  
 Sheikhs, 40, 44, 59, 62, 64, 65  
 Sheikh, Wadi el, 17, 60, 61, 62, 63, 64, 66, 74,  
 75, 76, 77, 90, 92, 100, 102, 103, 180, 183,  
 191, 193, 195, 196, 202-203, 213  
 Shejera, Gebel Abu, 84  
 Shellâl, Wadi, 16, 25, 38, 39, 41, 42, 128, 145,  
 146, 155, 164, 165, 167, 168, 172, 175, 175,  
 176, 177, 179, 183, 192, 198, 199  
 Shell-sand, 36  
 Shêqer, Gebel Abu, 187  
 —, Naqb, pass of, 46-47, 47, 63, 192  
 —, Wadi, 17, 46, 47, 92, 162, 180, 188, 194,  
 195, 197  
 Sherm Bay, 88  
 —, Bir, water in, 89  
 Shia plants, 27; bushes, 41, 50; 51, 68  
 Shiddiq, Gebel, 83, ridge of, 86  
 —, Wadi, 85, 86, 96, 99, 100, 187, 192, 205  
 Shinener, Gebel, 56, 58, 77  
 Shingle, flint-, 108  
 Shittah trees, (*Acacia Seyal*) :—see Seyal trees.  
 Shittim trees, 55  
 Sho'eib, Sikket, 72  
 —, Wadi es, 66  
 Shomer, Gebel Um, 13, 58-59, 73, 74, 80, 83,  
 86, 87, 176, 187, 195, 195  
 Sh'reich, Wadi, 66, 67, 69, 70, 72  
 Sia, Wadi, 35  
 Sidr trees, 44, yielding nebk fruit, 59; 63, 82  
 Sidri, Fersh, 49, 50, 194  
 —, Gebel Um, 87, 187  
 —, Sêh, and El Markhâ, plain of, 15-16  
 —, Sêh, water-course of, seyal trees in, 39  
 —, Wadi Sêh, 23, 24, 25, 39, 40, 41, 43, 46, 49,  
 50, 101, 108, 115, 135, 144, 152, 157, 164, 165,  
 172, 173, 174, 175, 177, 178, 183, 192, 193, 197,  
 202, 210  
 Sifsaf, Wadi, 87  
*Sigillaria*, 161  
 Sigilliyeh, Gebel, 77, 81; Sigillia, 190  
 —, Wadi, 57, 77-78  
 Sikket Abbas Pasha, 14, 80  
 — er Reeshshah, 57  
 — Sadur, 57  
 — Sho'eib, 72  
 — Syedna Musa, 71, 72  
 Silfa, Wadi Um, 32, 33, 34, 154  
 Silica, 162, 206  
 Siliceous sandstone, beds of, 163



- Tarfa, Wadi Abu, 88  
 Tarfat el Gidarén, 65  
 Tarr, Wadi el, 51, 53  
 Tasot Sadr, Gebel :—see Sadr, Gebel.  
 Tasot, Wadi Um, 35  
 Tatar el Dahami, Gebel, 16, 45, 49  
 Tayiba, Gebel, 48, 50, 79, 83  
 —, Wadi, 25, 26, 35, 48, 49, 50, 79, 84, 92,  
 106, 117, 134, 147, 150, 174, 178, 181, 185,  
 198, 200, 204  
 Tectonic geology of Western Sinai, 171-184  
*Tectus*, cf. *ornatus*, 130  
 Teeth, sharks', numerous large, 120 : of fish,  
 126, 140 ; numerous, in a bone bed, 208  
 Telegraph-line from El Tor to Suez, 14, viâ  
 El Qâ, 25 ; in Wadis Shebêka and Ethâl, 26-  
 27 ; 150  
*Tellina*, 123  
 Temalli, Gebel, 187, foothills of, 187  
 Temân, Gebel, 187  
 —, Wadi, 195  
 Temperature, 14, 90  
*Terebra*, 104  
 — *conobrina*, 104, 105  
 — *duplicata*, 104  
 Terraces, 25, 41, 46, 61, 64, 65, 75, 76, 82, 84,  
 86-88, 143, 159  
 Tertiary beds, 106-130, 134, 135, 143, 149, 150,  
 174, 175  
*Textularia agglutinans*, 129  
 Thaghadi, Gebel, 141  
 —, Wadi, 13, 22, 23, 127, 141, 143, 154, 155,  
 156, 172, 177  
 Thaghed, Wadi, 13  
*Thamnastraea decipens*, coral-like, 153  
 Themâm, Gebel, 87  
 —, Wadi Abu, 23, 87, 97, 100, 142  
 Themelli, Gebel, 86  
 —, Wadi, 86, 97  
*Thersites*, 127, beds of casts of, 140  
 — *gracilis*, 130  
 —, sp. nov., 130  
 Thickness :—see Height.  
 Thradi, Gebel, 141  
 —, Wadi, 141  
 Ti, El, plateau of, 17, 27, 28 ; table-land of,  
 32 ; 33 ; escarpment of, 74, due to the action  
 of wind on the sandstone, 90 ; 181  
 —, Gebel el, 28, 35, 38, 46, 48, 58, 91, 108,  
 124, 125, 132, 132, 148, 148, 149, 150, 155,  
 157, 158, 159, 161, 163, 164, 176, 178, 216  
 Tigellia, Gebel, 22  
 Tihl, Gebel, 88, of red granite, 186 ; 195, 212  
 Tilted beds, &c., 18, 21, 23, 26, 41, 64, 113, 117,  
 136, 137, 141, 144-146, 148, 175, 177, 179, 200  
 Tima, Gebel, a jagged ridge, 89  
 T'lah, Wadi et, 70, 76  
 Tobacco, Bedawin gardens of, 59  
 Tombs, 40, 59, 64, 65.—See also Burial-grounds.  
 Topography, 13-93  
 Tor Bay, 15  
 —, El, 13-16, 18, 19, 24, 25, 56, 58, 76, 85,  
 91, 96, 98, 99, 103-105, 109, 110, 123, 150, 205  
 Torrents, 14, 18, 32, 35, 41, 53, 54, 56, 59, 60,  
 71, 76-78, 80-82, 96, 97, 213, 215  
 Tortonian fossils, 106  
 Towara tribe, 62, 144  
*Trachycardium peregrinum*, 99  
 Traditions :—see Legends.  
 Transport, means of, 205 ; cost of, 207  
 Trees :—see Ban ; Fig ; Fruit ; Gharqad ;  
 Ilban ; Lassaf ; Markh ; Moina ; Palm ;  
 Retem ; Seyal, (Acacia Seyal, or Shittah) ;  
 Shittim ; Sidr ; Tarfa, (or Tamarisk).  
 — and plants, altitude-zone of the habitats  
 of, 85, 91-92  
 Trefoil, a, *Trigonella stellata*, 17  
 T'reif, Gebel Abu, 67  
 Triassic period, 155, 161  
 Triangulation :—see Trigonometrical.  
*Tridacna*, fragments of shell like, 114  
*Triforis*, 104  
 — *perlatus*, 104  
*Trigonella stellata*, a trefoil, 17  
 Trigonometrical stations of Ordnance Survey,  
 24, 30, 55  
 Troughs, (or basins), 67, 139, 144, 147, 173, 174,  
 181.—See also Synclines.  
*Truncatulina umbonifera*, 126  
 Tuff, brown-red, 118  
 Tura, Gebel, 181  
*Turbo radiatus*, 103  
 Turonian beds, 151  
 — period, 132  
 Turquoise mines, in Gebel Maghara, 37, 39,  
 worked by Major Macdonald, 39 ; names and  
 descriptions of various ; ancient Egyptian  
 workings, 40 ; in Wadi Serabit el Khâdim,  
 45 ; 120, in Wadi Qena, 164 ; in Wadi  
 Qenaia, 165 ; ancient Egyptian workings,  
 169 ; in Gebel Maghara, 199, and in Serabit  
 el Khâdim, 209 ; in Wadis Qenaia, Qena, and  
 Sidri, with their distinctive names, 210 ; the  
 richest ; Bauerman on, 211 ; 211-212

Silt, 100  
 Sin Bisher :—*see* Bisher.  
 Sinai, Eastern, rifts in, 180  
 —, Mount, 67, 107, 183, 184, 187  
 —, Northern, 92, 129, 185  
 Siq, Wadi, 16, 17, 38, 45, 45, 46, 47, 48, 49, 62,  
 83, 84, 85, 158, 162, 180, 189, 193, 194, 197,  
 201  
 Siqillia, Gebel, 80, 83  
*Sistrum elatum*, 104  
 Slag, copper, heaps of, in Wadi Nasb, 44 ; on  
 Gebel Safariat, also containing manganese, 208  
 Slickensides, abundant, 165  
 Snakes, 92  
 Snow, 74, 91, 213, 214  
 Solâf, Wadi, 60, 61, 64, 74–78, 90, 100, 102, 185,  
 191, 193  
*Solecurtus*, cf. *strigilatus*, 123  
 Solêf, Wadi, 62–65, 180  
*Solenastrea turonensis*, 122, 123  
*Spar*, dog-tooth, 140  
*Spatangus ocellatus*, (= *Maretia Fuchs*), 119  
*Sphaerulites*, 132  
 — *Lefebvrei*, 153–154  
 Spherulitic felsite, veins of, 188, 189  
*Spirifer*, 161, 166, 167  
 — *convolutus*, 171  
 — *striatus*, 171  
 — —, var. *attenuatus*, 171  
 — *trigonalis*, var. *crassus*, 171  
*Spondylus*, 122  
 — *aculeatus*, 104  
 — *Egyptiacus*, 130  
 Springs :—*see* Water.  
 Stations, trigonometrical, of the Ordnance  
 Survey, 24, 30, 55  
 Steamers, service of, from Suez to El Tor, 15  
 Steel, manganese-, 207  
*Stenopora*, 171  
 Stephanos, St., 71  
 Steps, 57, 58, 71, 72, 77  
*Stomatella*, 103  
 Stone circles in Wadi Nisrin, 50  
 Streams, 42, 79.—*See also* Water.  
*Streptorhynchus crenistria*, 161  
*Strombus fasciatus*, 104  
 —, cf. *Mermeti*, 132  
 — *tricornis*, 104, 105  
 Strontium sulphate, (celestine or), veins of, 107,  
 120 ; and analysis of, 209  
 Subsidence, 25, 79, 100, 125, 129, 162, 169, 181,  
 182, 201, 204, 215

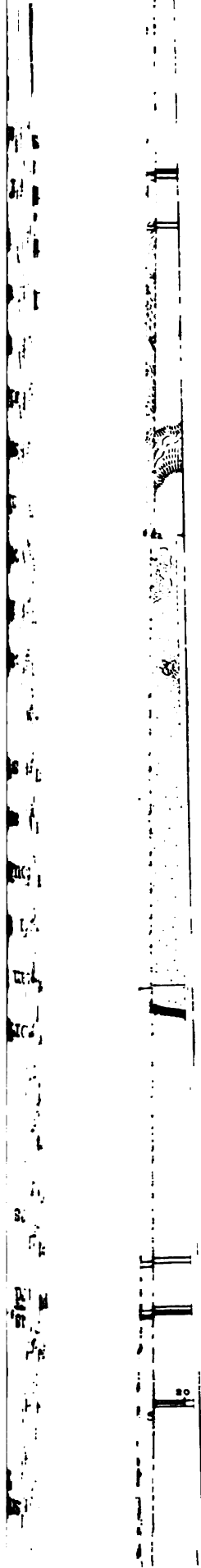
Sudr, Gebel, 125  
 Sudud, Wadi el, 65, 66, 70  
 Sues, work by, 171  
 Suez, 14, 15, 17, 22, 24–29, 31–37, 50, 62, 85,  
 92, 102, 120, 125, 131, 150, 174, 181, 204, 205,  
 208  
 — Canal, the, 37, 102  
 —, Gulf of, 13, 15, 25, 30, 31, 58, 72, 74, 107,  
 118, 120, 129, 129, 147, 152, 168, 171, 172,  
 173, 174, 180–182, 185, 189, 200  
 —, Isthmus of, 101, 181, 181  
 Sufsafah, Ras, 67–74, 78.—*See also* Safsâfa.  
 Sull'a, Gebel, 56, 59  
 Sulphate, Strontium-, 107, 120, 209  
 Sulphur, 147  
 Survey, Ordnance :—*see* Ordnance Survey.  
 Suwêra, Gebel Abu, 19, 110, 156 ; 173, 189  
 —, Wadi Abu, 19, 110  
 Suwiq, Wadi Naqb, 17, 43, 44, 45, 49, 180, 183, 198  
 Syedna Musa, Sikket :—*see* Musa.  
 Syene, syenite found at, near the First Cataract,  
 Aswan, 183  
 Syenite, 52, 182, 183, 194, 195, 204  
 — felsite, 188, 196, 204  
 — granite, 66, 73, 74  
*Symphylia*, 121  
 Synclines, 23, 111, 112, 113, 115, 115, 119, 135,  
 137, 139, 141, 143, 144, 147, 149, 159, 165,  
 173, 175, 177.—*See also* Troughs.  
 —, Cretaceous limestone, 117  
 —, gypsum, 119–120  
*Syringopora* aff. *ramulosa*, 171

## T

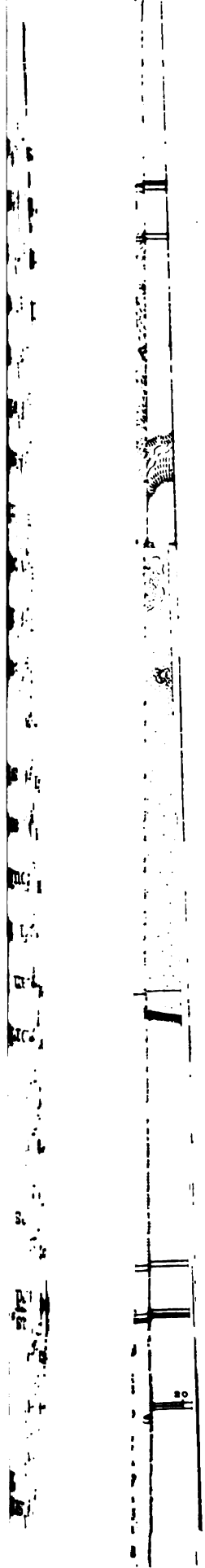
TABLE-LAND, 32, 33, 35, 36, 49, 52  
 —, marls, of, 36  
 Tachylite, a few veins of, 25  
 Tachylitic basalt, black veins of, 198  
 — dykes, 147, 198  
 Tahuneh, Gebel et, a fine prospect from, 56  
 Takha, Beidhat Um, 77  
 —, Wadi Um, 77  
 Talib, Wadi Abu, 76  
 Tamarisk :—*see* Tarfa.  
*Tapes virginiae*, 105  
*Tapes virginia*, 105  
 Tarbush, Gebel, of the Ordnance Survey  
 map :—*see* Morsia, Gebel.  
 Tarfa bushes, (or tamarisk), 14, 26, 28, 29, 31,  
 32, 35, 37, 38, 43, 50, 55, 59, 60, 65, 75, 79,  
 80, 82, 84, 85, 88, 91, 92, 102, 103

- Tarfa, Wadi Abu, 88  
 Tarfat el Gidarân, 65  
 Tarr, Wadi el, 51, 53  
 Taset Sadr, Gebel :—see Sadr, Gebel.  
 Taset, Wadi Um, 35  
 Tatar el Dahami, Gebel, 16, 45, 49  
 Tayiba, Gebel, 48, 50, 79, 83  
 —, Wadi, 25, 26, 35, 48, 49, 50, 79, 84, 92,  
 108, 117, 134, 147, 150, 174, 178, 181, 185,  
 198, 200, 204  
 Tectonic geology of Western Sinai, 171-184  
*Tectus*, cf. *ornatus*, 130  
 Teeth, sharks', numerous large, 120: of fish,  
 126, 140; numerous, in a bone bed, 208  
 Telegraph-line from El Tor to Suez, 14, via  
 El Qâ, 25; in Wadis Shebêka and Ethâl, 26-  
 27; 150  
*Tellina*, 123  
 Temalli, Gebel, 187, foothills of, 187  
 Temân, Gebel, 187  
 —, Wadi, 195  
 Temperature, 14, 90  
*Terebra*, 104  
 — *consobrina*, 104, 105  
 — *duplicata*, 104  
 Terraces, 25, 41, 46, 61, 64, 65, 75, 76, 82, 84,  
 86-88, 143, 159  
 Tertiary beds, 106-130, 134, 135, 143, 149, 150,  
 174, 175  
*Textularia agglutinans*, 129  
 Thaghadi, Gebel, 141  
 —, Wadi, 13, 22, 23, 127, 141, 143, 154, 155,  
 156, 172, 177  
 Thaghad, Wadi, 13  
*Thamnastraea decipiens*, coral-like, 153  
 Themâm, Gebel, 87  
 —, Wadi Abu, 23, 87, 97, 100, 142  
 Themelli, Gebel, 86  
 —, Wadi, 86, 97  
*Thersites*, 127, beds of casts of, 140  
 — *gracilis*, 130  
 —, sp. nov., 130  
 Thickness :—see Height.  
 Thradi, Gebel, 141  
 —, Wadi, 141  
 Ti, El, plateau of, 17, 27, 28; table-land of,  
 32; 33; escarpment of, 74, due to the action  
 of wind on the sandstone, 90; 181  
 —, Gebel el, 28, 35, 38, 46, 48, 58, 91, 108,  
 124, 125, 132, 132, 148, 148, 149, 150, 155,  
 157, 158, 159, 161, 163, 164, 176, 178, 216  
 Tigella, Gebel, 22  
 Tihl, Gebel, 88, of red granite, 186; 195, 212  
 Tilted beds, &c., 18, 21, 23, 26, 41, 64, 113, 117,  
 136, 137, 141, 144-146, 148, 175, 177, 179, 200  
 Tima, Gebel, a jagged ridge, 89  
 T'lah, Wadi et, 70, 76  
 Tobacco, Bedawin gardens of, 59  
 Tombs, 40, 59, 64, 65.—See also Burial-grounds.  
 Topography, 13-93  
 Tor Bay, 15  
 —, El, 13-16, 18, 19, 24, 25, 56, 58, 76, 85,  
 91, 96, 98, 99, 103-105, 109, 110, 123, 150, 205  
 Torrents, 14, 18, 32, 35, 41, 53, 54, 56, 59, 60,  
 71, 76-78, 80-82, 96, 97, 213, 215  
 Tortonian fossils, 106  
 Towara tribe, 62, 144  
*Trachycardium peregrinum*, 99  
 Traditions :—see Legends.  
 Transport, means of, 205; cost of, 207  
 Trees :—see Ban; Fig; Fruit; Gharqad;  
 Ilban; Lassaf; Markh; Moïna; Palm;  
 Retem; Seyal, (Acacia Seyal, or Shittah);  
 Shittim; Sidr; Tarfa, (or Tamarisk).  
 — and plants, altitude-zone of the habitats  
 of, 85, 91-92  
 Trefoil, a, *Trigonella stellata*, 17  
 Treif, Gebel Abu, 67  
 Triassic period, 155, 161  
 Triangulation :—see Trigonometrical.  
*Tridacna*, fragments of shell like, 114  
*Triforis*, 104  
 — *perlatus*, 104  
*Trigonella stellata*, a trefoil, 17  
 Trigonometrical stations of Ordnance Survey,  
 24, 30, 55  
 Troughs, (or basins), 67, 139, 144, 147, 173, 174,  
 181.—See also Synclines.  
*Truncatulina umbonifera*, 126  
 Tuff, brown-red, 118  
 Tura, Gebel, 181  
*Turbo radiatus*, 103  
 Turonian beds, 151  
 — period, 132  
 Turquoise mines, in Gebel Maghara, 37, 39,  
 worked by Major Macdonald, 39; names and  
 descriptions of various; ancient Egyptian  
 workings, 40; in Wadi Serabit el Khâdim,  
 45; 120, in Wadi Qena, 164; in Wadi  
 Qenaia, 165; ancient Egyptian workings,  
 169; in Gebel Maghara, 199, and in Serabit  
 el Khâdim, 209; in Wadis Qenaia, Qena, and  
 Sidri, with their distinctive names, 210; the  
 richest; Bauerman on, 211; 211-212









2

3

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5

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GEOLOGY

Sheet 2024

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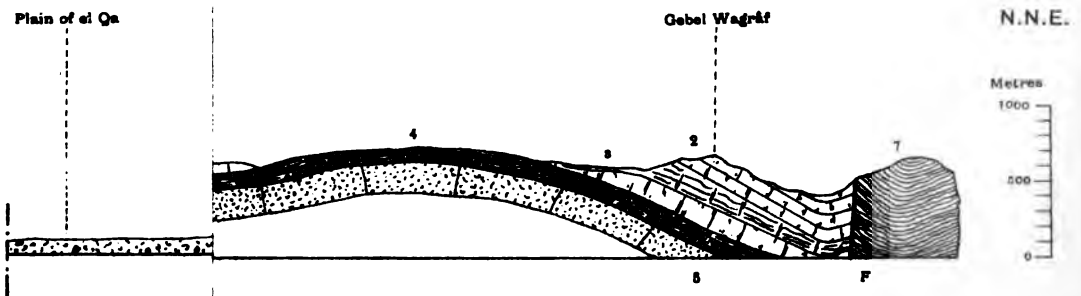
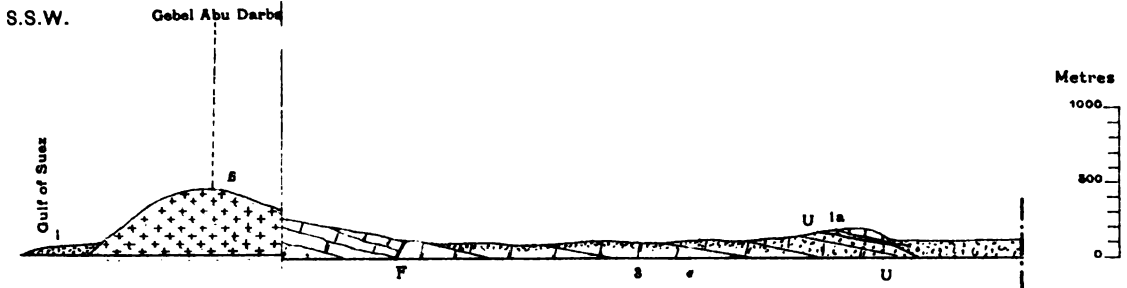
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# O THE METAMORPHIC AREA.



- 5. Nubian Sandstone.
- 6. Granite.
- 7. Gneiss.
- F. Faults.
- U. Unconformability.

# THE HISTORY OF

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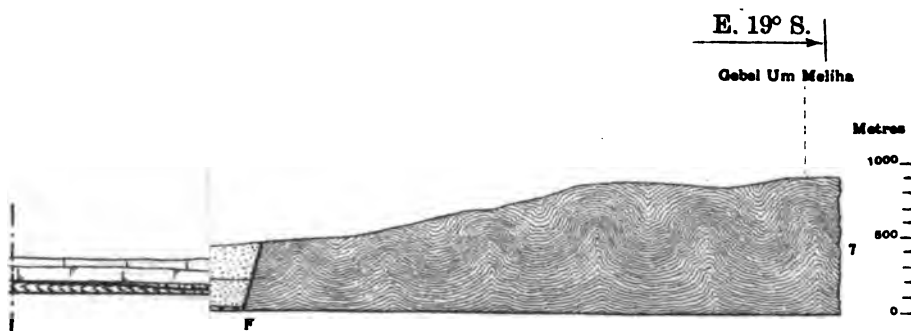
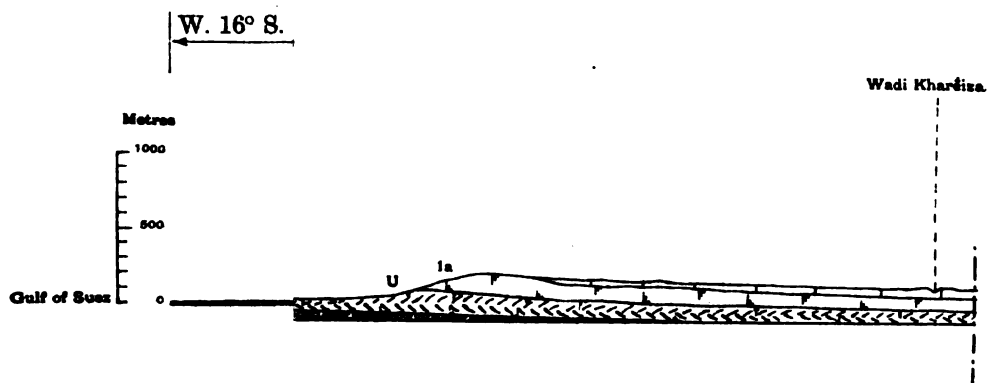
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# GEBEL MELIHA.



- PLEIST 5. Sandstone.
- MIOCEI 6. Red Granite (probable extension).
- CRETAC 7. Gneiss.
- F. Faults.
- U. Unconformability.

SECTION FROM GEBEL NIS

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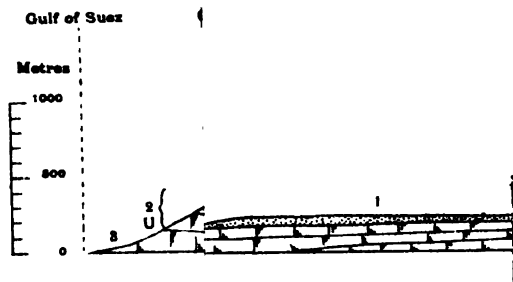
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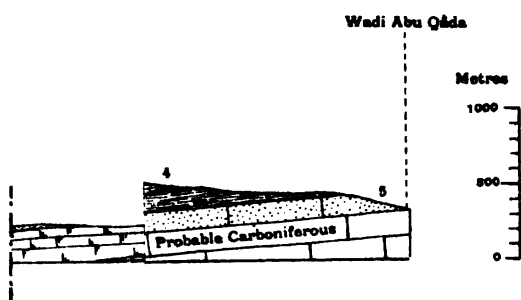
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S.W.



N.E.



- |          |        |                      |
|----------|--------|----------------------|
| MIocene  | 1. RT) | 4. Cretaceous Marls. |
|          | 2.     | 5. Nubian Sandstone. |
| SENONIAN | 3.     | F. Faults.           |

1. The first part of the report is a general introduction to the subject of the study.

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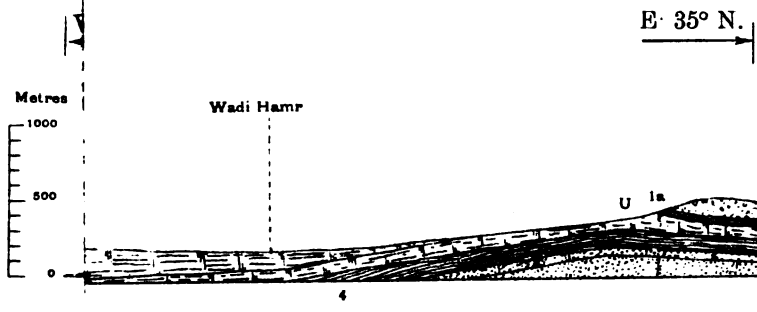
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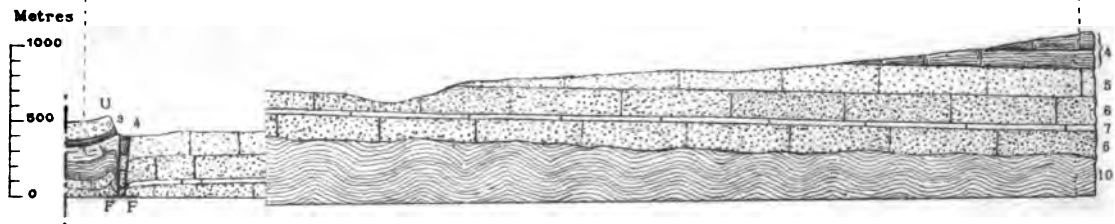


W. 14° S

Gebel Sarbut el Gemel

E. 14° N.

Gebel el Ti



- 6. Carboniferous Sandstone.
- 7. Bed of limestone in No. 6.
- 8. Porphyrite flow, contemporaneous with No. 2.
- 9. Basic dyke in Cretaceous limestone.
- 10. Gneiss.
- F. Faults
- U. Unconformability.



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